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ENDOTHELIAL MYELOMA

An Analysis of Cases*

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Endothelial myeloma, or Ewing's tumor, has been accepted as a well known clinical entity, distinct and different from other tumors occurring in bone. However, there still remains much doubt as to the exact nature of the tumor. In the Registry of Bone Sarcoma of the American College of Surgeons are 722 osteogenic sarcomata as compared with 162 endothelial myelomata, but this does not take into consideration the number of cases which are never registered and which, in all probability, are treated throughout, until death ensues, as osteomyelitis, general sepsis, or some other condition. Therefore, it is quite probable that this tumor is of more frequent occurrence than is generally known. Ewing describes three types of endothelioma: (1) multiple endothelioma; (2) solitary angio-endothelioma; (3) diffuse endothelioma, or endothelial myeloma. In this discussion we are concerned only with the third type, which is the tumor known as Ewing's tumor. The fact that this tumor is a clinical entity was discovered by its favorable response to irradiation by x-ray or radium. Such response is of greater degree than that from any other known tumor of bone.

The gross appearance as described by Geschickter and Copeland is as follows: "The tumor itself, enclosed by this capsule, was firm and grayish-white and was divided into characteristic lobules by a number of connective tissue strands extending from the outer capsule to the region of the cortical bone. Occasionally, the tumor substance showed cysts, filled with a dark, pigmented, jelly-like material. These cysts were due to hemorrhage or regressive changes, for many specimens showed soft necrotic areas honeycombing their structure."

Ewing defines the microscopic appearance as follows: "The structure presents diffuse sheets of small polyhedral cells with clear cytoplasm,

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without intervening stroma, often undergoing mucoid or hydropic degeneration. Zenker's solution best preserves the cell form. After poor fixation, the tissue resembles that of a myeloma or 'round cell sarcoma'. That the cells are endothelial is shown by the appearance in some cases of many spaces lined by tumor cells and filled with intact blood. The structure may approach that of angio-endothelioma or it may verge on myeloma. Plasma cells are absent or scanty and uncertain; but the possible relation of this tumor to plasma cell myeloma remains to be determined."

The shafts of the long bones are the most frequently involved, in the following order: tibia, femur, humerus, and fibula. The flat bones, though less often affected, may be involved as follows: pelvis, scapula, clavicle, and rib. There may be general or local involvement of the lymphatic glands, and metastases to the skull and other bones are not uncommon. Multiple simultaneous involvement has been suggested, but this is hardly probable as, in all malignant tumors of bone, metastasis to the lungs is of frequent occurrence. A history of trauma is present in about forty per cent. of the cases. The tumor is rare in persons over twenty years of age. The characteristic symptoms are pain and swelling,—at first intermittent, then more or less constant as the tumor progresses in size. The attacks are associated with a moderate elevation of temperature and leukocytosis. In rare cases the temperature may reach 103 or 104 degrees Fahrenheit. The white-cell count is normal or slightly increased, seldom reaching 12,000 to 15,000. On deep palpation, in the early stage, the pain is exquisite, indicating increased intra-osseous pressure. After the tumor has broken through the periosteum, there is less local tenderness and the pain usually decreases. In the case of the long bones, the roentgenogram is described as demonstrating an invasive, expansive, striated tumor, with destruction in the medulla but reaction on the part of the periosteum, producing parallel layers of bone (onion-like) over the periphery. The process is destructive, the new bone being merely reactive. In the flat and cavernous bones, like the ilium, there are areas of destruction and condensation, with slight gross enlargement but no periosteal proliferation.

Tumors of bone may be classified as osteogenic,—that is, derived from tissues which are concerned with the process of bone production—and non-osteogenic,—that is, derived from tissues residing in bone, but which are in no manner concerned with the manufacture of bone, as marrow tissue, reticulo-endothelium, vascular and lymphatic endothelium. Endothelial myeloma, according to its behavior, is in all probability non-osteogenic, but there is much difference of opinion as to the origin.

Prior to the report of Ewing's first case, endothelial myeloma was usually described as round-cell sarcoma. One can easily recognize such a tumor; it has been more or less clearly defined by many authors, but especially by Gross in his classic article published in 1879. It is also interesting to note that Howard and Crile in 1904 reported one case of a tumor in a child of eleven years, arising from the capillaries and

perivascular lymph spaces of the bone marrow, which was very suggestive of round-cell sarcoma and which was defined as "endothelioma". Endothelioma, even at present, is a very vague term and many authorities doubt the existence of such a tumor. Ribbert says: "In no instance has it been proven that so called endothelioma originated from endothelium". Kolodny believes that the nature of the tumor can only be determined by tracing the cell to the point of origin, which he claims to have accomplished in the case of the very rare tumor of bone, angio-endothelioma, but not in that of endothelial myeloma or of Ewing's tumor. Kolodny added the term myeloma to that of endothelioma, as he believes, as does Ewing, that the origin is in the marrow. Geschickter and Copeland do not believe that the tumor is derived from the marrow, and suggest the periosteum or the cortex as the possible source. They further state that the tumor is neither an endothelioma nor a myeloma. Hirsch and Ryerson report a very unusual case in a boy aged six years. The case was first diagnosed as osteomyelitis and an open operation was performed. This was followed by tumefaction, and a further diagnosis of endothelioma was made by several competent pathologists. After death an autopsy revealed the tumor to be a metastatic carcinoma from the bronchial tubes of the lungs. These authors have also reported three other similar cases of bone tumors, in elderly patients, in which there had been a diagnosis of endothelioma but autopsy demonstrated a primary focus of carcinoma in the lungs. These cases, as well as the fact that endothelial myeloma is occasionally multiple and involves many bones, suggest the probability that the tumor is metastatic and possibly not a primary tumor. Geschickter and Copeland, however, call attention to the pertinent fact that in an appreciable percentage of cases the patients are cured by radical excision or amputation alone; therefore, they conclude that the tumor must be of primary origin in the bone. However, it is a well known fact that metastatic thyroid tumors in bone are often cured by local treatment or radical removal without excising the primary tumor.

McWhorter, Foot, and others believe that the cells of the tumor more closely resemble lymphocytes, and that, as the response to radium and x-ray so closely resembles the rapid recession in tumors composed of cells of this type, the tumor is of the nature of a lymphosarcoma, a reticuloendothelioma, or Hodgkin's disease. The difference is one of degree rather than of kind. McWhorter further says that no one can definitely state that the cells in Ewing's tumor are endothelial.

Clark has demonstrated by experiment that endothelium may be produced in any type of ordinary connective tissue by a non-irritating foreign body. Such a condition could obviously be induced by trauma, causing an area of aseptic necrosis. It is also true that endothelial cells are found as a constituent of low-grade inflammatory tissue from many causes, which has been suggested as a possible source of origin.

To summarize: (1) There seems to be a difference of opinion as to the actual existence of any type of endothelioma; (2) there is no agreement as

TABLE I

CASES OF ENDOTHELIAL MYELOMA (REGISTERED)

Case No.	Name	Age	Sex	Onset *	Location	Duration on Admission	Operation for Osteo-myelitis	Treatment	Duration After Treatment
1	E. R.	7	F	I	Left fibula	6 months	0	X-ray	Died in 4 ½ years
2	A. L. M.	47	M	I	Right tibia	1 year	0	Amputation, x-ray, Coley toxins	Living and well, 7 years
3	S. S.	13	F	S	Left ilium	9 months	0	X-ray, Coley toxins	Died, 8 months
4	B. A. W.	16	M	S	Left tibia	6 months	0	None	Died, 6 months
5	E. S.	13	F	I	Left femur	1 year	2	None	Died, 2 months
6	K. H.	52	F	I	Left tibia	3 years	0	Amputation	Died, 5 months
7	J. O. T.	21	M	S	Right tibia	4 months	2	X-ray, Coley toxins	Living and well, 4 years
8	E. L.	12	F	I	Left tibia	2 years	1	Amputation, x-ray, Coley toxins	Living and well, 3 years
9	W. T. S.	20	F	S	Right tibia	1 year	0	Amputation, x-ray	Died, 1 year, 11 months
10	E. G.	16	M	I	Left femur, upper third	5 months	0	X-ray, Coley toxins	Died, 5 months
11	W. W. M.	39	M	I	Left pubis	1 year	0	X-ray	Died, 8 months

* I: slow and insidious onset; S: sudden onset.

TABLE II

CASES OF ENDOTHELIAL MYELOMA (NOT REGISTERED)

Case No.	Name	Age	Sex	Onset *	Location	Duration on Admission	Operation for Osteo-myelitis	Treatment	Duration After Treatment
12	S. E.	8	M	I	Upper extremity, femur	3 months	0	None	Died in 8 months
13	J. B.	15	F	I	Upper extremity, right femur	3 months	0	None	Died in 4 months
14	L. L.	7	F	I	Lowerthird, left femur	15 months	0	None	Died in 5 months
15	I. C.	14	M	I	Upper half, right femur	4 months	1	Drainage	Died in 4 months
16	L. L.	6	M	I	Lower half, left femur	1 month	0	Amputation	Died in about 6 months
17	E. H.	10	F	I	Rib	4 months	0	X-ray	Living, 2 months

* I: slow and insidious onset; S: sudden onset.

to the histogenesis of Ewing's tumor; (3) the suggestion has been made that it could be a metastatic lesion; (4) on account of the resemblance to lymphatic tissue and the reaction to radiation, it is suggested that the tumor may be some type of lymphosarcoma or reticulo-endothelioma; (5) as endothelium is found in low-grade inflammatory tissue, and the symptoms often closely resemble acute inflammation, infection has been suggested as a possible etiological factor.

This discussion is based on twenty-three cases which present factors more or less suggestive of endothelial myeloma. Seventeen of these have been submitted to the Registry of Bone Sarcoma of the American College of Surgeons. Three cases in which the final diagnosis was inflammation are placed in a separate class on account of their value from a differential diagnostic standpoint. In three cases a diagnosis of malignancy was made, but there was not sufficient agreement for definite classification. In six cases, not registered, there is sufficient evidence to warrant the diagnosis of Ewing's tumor; these will be considered in a separate group. Excluding those cases in which the diagnosis of inflammation was proved, the remainder may be divided as follows: (1) endothelial myeloma, confirmed by the Registry of Bone Sarcoma, eleven cases; (2) endothelial myeloma not submitted to the Registry of Bone Sarcoma, six cases; (3) unclassified sarcoma, confirmed by the Registry of Bone Sarcoma, three cases. The essential features of Classes 1 and 2 are presented in Tables I and II.

A review of the roentgenograms of the seventeen cases in the two tables demonstrates that there are eleven tumors in the shafts of the long bones, two near the ends of the long bones, one (patient aged fifty-one) on the end of the bone, one in the ilium, one in the rib, and one in the pubic bone. The changes in the shafts are characteristic in the young, and may be described in three different stages: (1) condensation of the shaft of the bone without reaction of the periosteum, as demonstrated in Case 7*; (2) the typical invasion with expansion, striation, and destruction of the cortex, and reactive bone production of the periosteum in layers (onion peel) as apparent in Cases 4, 12, 14, and 15; (3) disintegration of the periosteal layers and shaft with extension of the tumor to surrounding parts. The remains of the periosteum are apparent by marked lipping near the junction of the normal shaft and the tumor. This is excellently illustrated in Cases 1, 2, 5, 8, and 13.

Duration of the different stages varies, as does the degree of malignancy present. There are probably atypical cases, in which the process is more or less varied. Lipping is described as one of the chief characteristics of osteogenic sarcoma, whereas it is of equal, if not more frequent, occurrence in Ewing's tumor. However, in the literature until recently differentiation has not been made between the manifestations of the x-ray in osteogenic sarcoma and those seen in Ewing's tumor. In only one or

* This stage, unfortunately, is observed rarely as most cases are not seen at so early a period; also it has not been observed in young children.

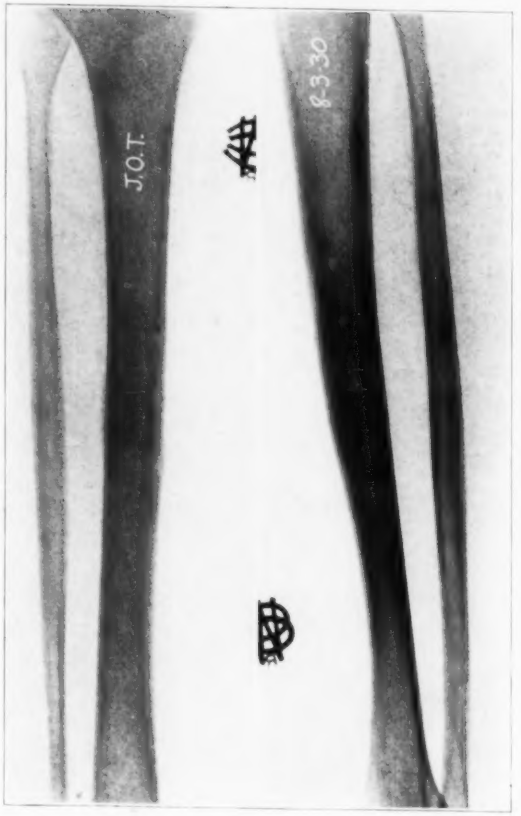

FIG. 1

Case 7. Man aged twenty-one. First stage of Ewing's tumor, showing only osseous condensation. Drill holes of operation for osteomyelitis 4 months previously.

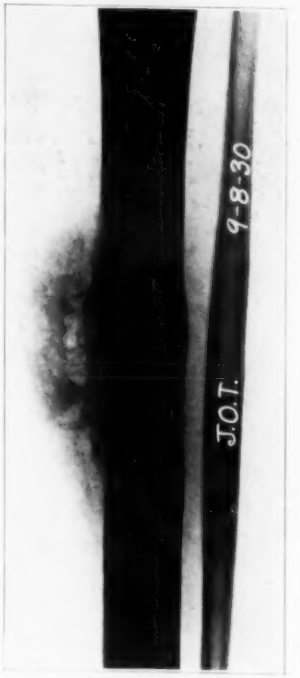

FIG. 2

Case 7. Showing extensive tumefaction six weeks after biopsy.

FIG. 3

Case 7. Two years after treatment with x-ray and Coley toxins. No recurrence at the present time, four years after beginning treatment.

possibly two cases have bone spicules been found at right angles to the long axis of the shaft in Ewing's tumor,—a reaction more frequent in osteogenic sarcoma in the young. This reaction may be observed in inflammatory lesions, and I have also been able to demonstrate the same osseous manifestation in one case of syphilis of the upper extremity of the femur. Any lesion which causes a gradual separation of the periosteum, with stretching of the blood vessels which supply the bone, may cause new bone to be formed parallel to the blood vessels which invade the bone at a right angle.

The macroscopic or gross pathology differs as do the x-ray findings. In the first stage, as demonstrated by the roentgenogram, only condensed bone may be observed; and within the marrow cavity the tissues may resemble grossly low-grade inflammation, as denoted by hyperaemia, and possibly slight increase of connective tissue, as found in osteomyelitis of Garrè. Specimens taken from the cortex and marrow may show characteristic tumor tissue, but this can easily be overlooked. In the second stage, the tumor, consisting of grayish-white, rather firm tissue, will be found between the layers of the periosteum and within the distended cortex and in the marrow. Also, there are usually necrotic areas with liquefaction, hemorrhage, and disorganization which may resemble pus. Such material may fill the marrow cavity and lead to errors in diagnosis. In the third stage, the tumor has broken through the periosteum and is of the character usually defined in text-books as "grayish-white, lobulated with areas of necrosis". In some instances there is extensive destruction so that a large portion is of brain-like consistency, more or less pigmented from repeated hemorrhages.

FIG. 4

Case 16. Boy, aged six. Typical Ewing's tumor in second stage with characteristic expansion, striation, and onion-peel reaction of periosteum.

Of the seventeen cases listed in Tables I and II there were four in which there had been operations for acute osteomyelitis. Three of these patients had been operated on prior to admission, and one by error on my part after admission.

Case 7 had had one operation, fifteen weeks prior to admittance, which consisted of drilling three holes in the tibia. The wound healed uneventfully with relief. About

two months later the symptoms became progressively more severe with afternoon temperature to ninety-nine degrees. One week prior to admission symptoms again became more exaggerated, with swelling and elevation of temperature to 100 degrees.

On admission there was pain and swelling, local heat, but no tumefaction in the tibia. Palpation and deep pressure caused exquisite tenderness. There was no elevation of temperature.

The white-cell count was 7,500,

Polymorphonuclear neutrophiles	60 per cent.
Lymphocytes	30 per cent.
Monocytes	3 per cent.
Eosinophiles	5 per cent.
Basophiles	2 per cent.

The hemoglobin was 90.

The roentgenogram demonstrated condensation of bone over about five inches in the middle third of the right tibia, no reaction on the part of the periosteum, and no increase in size of the bone, but merely a change in density.

The bone was explored with the idea that we were dealing with an inflammatory lesion; a large trap-door incision was made and a vaselin-gauze pack inserted. The marrow appeared slightly congested, but there was absolutely no evidence of a tumor of any kind. A culture was made, which proved negative. In about ten days the laboratory reported a malignant tumor, but the patient had returned to his home apparently relieved. Specimens were sent to other authorities for opinions, which varied, but all agreed as to malignancy.

In the meantime we were in constant touch with the patient, and at the end of about

FIG. 5

Anteroposterior view.

FIG. 6

Lateral view.

Case 1. Girl aged seven. Third stage of endothelial myeloma, showing marked lipping.

six weeks the symptoms recurred with increased severity. The patient returned, showing definite growth over the area involved. The roentgenogram revealed tumefaction in the soft parts through the operative wound. Biopsy was again performed to determine whether or not an amputation was needed, as the tissue previously removed was not grossly characteristic. A diagnosis of malignancy could not be made from the tissue removed at the second biopsy and, therefore, amputation was not performed. X-ray treatment and Coley toxins were administered with rapid recession of the tumor and complete healing of the wound. This patient has remained well and healthy for a period of four years since treatment was instituted. The case will be discussed later.

In Case 15, seen about ten years ago, the diagnosis of osteomyelitis was made. An operation was carried out, and treatment continued for several weeks before malignancy was suspected.

This case, a boy fourteen years of age, was brought into the hospital with excessive pain in the upper extremity of the femur. His temperature was 101 degrees. The total white-cell count was 10,000 (polymorphonuclear neutrophiles 62 per cent., and lymphocytes 38 per cent.).

The roentgenogram demonstrated typical Ewing's tumor at the second or most common stage, but, nevertheless, a diagnosis was made of osteomyelitis. The history was typical of osteomyelitis according to the hospital record.

At operation material was found that closely resembled pus, and Dakin's tubes were inserted. Progress was not satisfactory, swelling increased, and the white-cell count rose to 29,000 (polymorphonuclear neutrophiles, 75 per cent., lymphocytes 25 per cent.), evidently due to secondary pyogenic infection.

At the end of six weeks a pathological fracture occurred, and a biopsy showed a very malignant tumor. Roentgenogram of the lungs demonstrated extensive metastases and the patient died within a few months. Further investigation of the history demonstrated an insidious onset and that the patient had been treated for malaria and rheumatism at varying intervals during the previous six months.

FIG. 7

Case 1. Both views one year later, after irradiation by x-ray. Patient remained well four and one-half years, with no local recurrence. Died of metastases.

FIG. 8

Case 8. Girl, aged twelve. Showing third stage of Ewing's tumor with marked lipping. No invasion of epiphysis. Patient remained well for three years after amputation.

In Case 7, even though the diagnosis was erroneously an inflammatory lesion, tissue examination demonstrated within a few days the true nature of the process, and treatment was instituted. In Case 15 valuable time was lost, much to the detriment of the patient, which caused him to lose what little chance of life there was. However, the tumor in this case was very malignant, death ensuing less than one year from the onset of symptoms.

An analysis of these two cases illustrates some very important factors: first, the blood findings alone should suggest a condition different from the average case of acute infectious osteomyelitis; second, the roentgenogram in Case 7 is not indicative of any one lesion, as many affections may cause similar changes, but in Case 15 the appearance of the roentgenograms was typical of endothelial myeloma and at the present time would be considered almost conclusive; third, the necessity of accurate records, regardless of the symptoms; fourth, the necessity of making a culture and microscopic examination of all pathological tissue, which has always been routine in our Clinic. This was carried out in Case 7, resulting in an early diagnosis and so far a most happy result. In Case 15, the operation was an emergency, and I presume in some way the culture and specimen were overlooked, as we could find no record of tissue examination.

FIG. 9

Case 2. Man aged forty-seven. Endothelial myeloma, involving lower end of tibia. Well seven and one-half years after amputation.

Of the seventeen cases in Tables I and II, only four gave a history of sudden onset, and in only one of these was the patient treated for osteomyelitis. In thirteen of the seventeen cases the onset was insidious, and it is quite probable that a history of previous symptoms could have been elicited in an even higher percentage, which is an important differential point in the diagnosis between Ewing's tumor and osteomyelitis.

Five of the cases in Table I had x-ray treatment and Coley's toxins (Cases 2, 3, 7, 8, and 10). Cases 2, 7, and 8 are living and well, seven, four and three years, respectively, after treatment was instituted. Cases 2 and 8 had amputation in addition to x-ray treatment and toxins, while Case 7 is living and well, with a normal leg, at the end of four years. Case 2 was a man forty-seven years of age, at which period of life the prognosis is better. The question of location also materially affects the result. In the two patients of this group who died, the tumor was within or in close proximity to the trunk, where the mortality is practically 100 per cent.,—in Case 3 in the ilium, and in Case 10 in the upper extremity of the femur. In two of the living cases amputation was employed, which, according to the report of Geschickter and Copeland, is successful in sixteen and five-tenths per cent.

The x-ray treatment alone was employed in two cases,—Case 1 and

Case 11. Case 1 is most interesting as there was complete recession for such a long period and apparent local cure.

This patient, a girl aged seven, gave a history of injury six months prior to admission, which was followed by pain and tumefaction and some intermittent symptoms, as redness and slight fever. On examination a definite tumor was found on the lower extremity of the left fibula. The roentgenogram demonstrated the third stage of Ewing's tumor as previously described. Biopsy was made and a typical Ewing's tumor was found. Amputation was advised but refused. X-ray treatment was administered by Dr. C. P. Rutledge, of Shreveport, Louisiana, with complete relief of all symptoms and a return of the bone structure to approximately normal. Four and one-half years later the patient died of pulmonary metastases, but there was no local recurrence. (See Figures 5, 6, and 7.)

In Case 11, the tumor was in the pubic region. Intensive x-ray treatment was given with decided improvement for a few months, but the patient died in eight months, from metastases.

A comparison of Case 1 with Case 7, is most interesting, as the conditions are parallel, with the exception of some disparity in ages,—Case 1, a girl of seven years, and Case 7, a man aged twenty-one. Both tumors were in the leg below the knee,—in Case 7 in the tibia and in Case 1 in the fibula. In Case 1 death from pulmonary metastases occurred four and one-half years after x-ray treatment, while in Case 7 the patient is living and well approximately four years after treatment with x-ray and Coley toxins.

The x-ray treatment or radium alone has not proved satisfactory. The only recorded case of a five-year cure by radiation that I have found, after extensive search, is in the work of Geschickter and Copeland, who report a case in the mid-shaft of the tibia, occurring in a woman aged twenty-two years. This case was quoted from an article of W. B. Coley and B. L. Coley, which very clearly states that both radiation and toxins were employed; in the age of the patient and location of the tumor this case is identical to Case 7 in this series.

The local response to x-ray may be in either one of two ways: first, there may be new reactive bone which gradually becomes organized with rapid recession of the tumor; later there is renewed growth of the tumor with disintegration but with no further response to x-ray treatment; second, there may be a complete recession with an apparent local cure, but with metastases later which do not respond successfully to treatment.

Cases 6 and 9 of Table I deserve discussion, for, if they are endothelial myeloma, they are more or less typical. Case 6 was in a woman fifty-two years of age, and in no manner did the clinical history or roentgenogram resemble Ewing's tumor. There was much difference of opinion among pathologists of the Registry, several suggesting metastatic carcinoma, which was also our opinion. In Case 9, when first observed, there was a history of intermittent pain and swelling about the middle of the left leg, of one year's duration. On examination there was very slight swelling about the middle of the right tibia, but no definite tumor. The roentgenogram was negative. Exploration was done at once with a trap door,

about two inches in length and one-half inch in width, into the bone. No gross or microscopic pathology was found, the tissues being normal. Six months later intermittent symptoms persisted, though with no definite changes manifested in the roentgenogram, and a second exploration was made. On the posterior and medial aspects of the tibia there was a small tumor about two inches in length and from one to one and a half inches in width. The tumor was apparently encapsulated, pale, and like fish flesh, evidently arising from the periosteum and only invading the bone from without through the trap-door incision. From the location and histopathology, our pathologist, Dr. J. F. Hamilton, made a provisional diagnosis of Ewing's tumor. All pathologists of the Registry

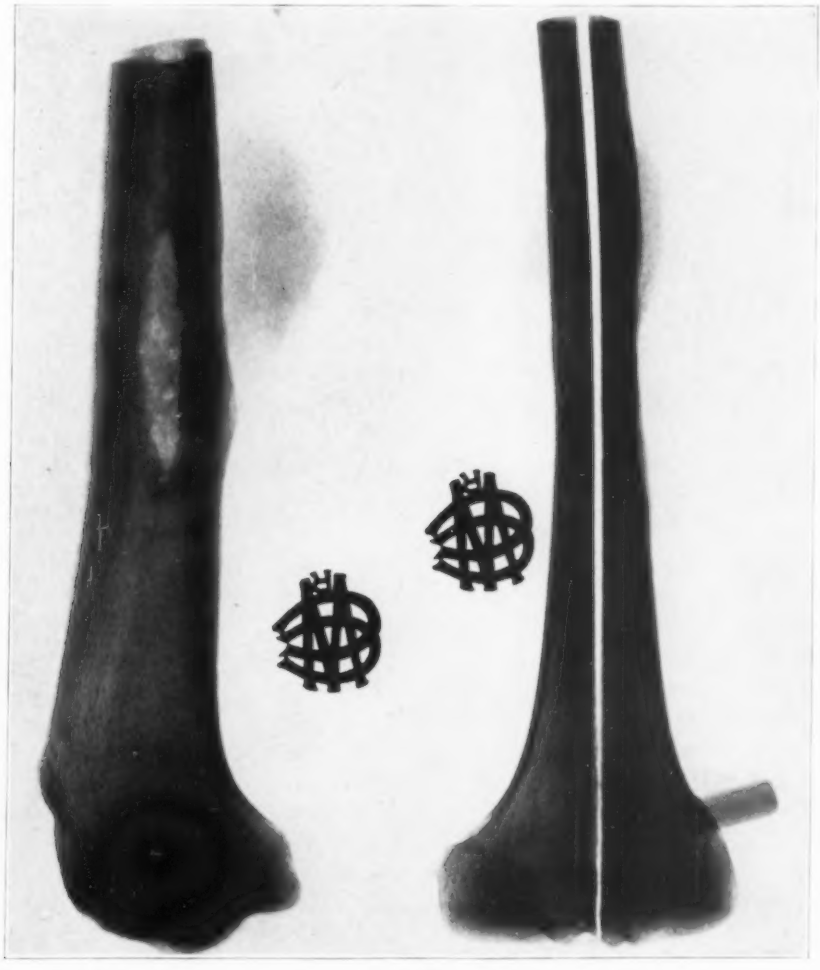

FIG. 10

Case 9. Woman aged twenty. Showing tumor, apparently extraperiosteal, after amputation. In this case roentgenograms were apparently negative prior to amputation.

FIG. 11

Case 10. Ewing's tumor of the upper end of the femur with pathological fracture and changes closely resembling osteomyelitis.

unanimously concur in the opinion that it is a case of Ewing's tumor. We have never seen, nor can we find report of, an endothelial myeloma with symptoms existing for a period of one year, without some structural changes within the bone demonstrable by the roentgenogram. If this was a Ewing's tumor, it forms a distinct type apparently originating in the periosteum.

In three of the cases in which we were suspicious of Ewing's tumor or inflammation, the Registry diagnoses are unclassified sarcomata.

One case, Mrs. I. N. D., aged fifty-one when first observed, complained of intermittent pain in the left tibia, which had existed for a period of four years. Examination revealed only tenderness, but no tumefaction. Roentgenograms demonstrated condensation about the middle third of the left tibia. At an exploratory operation, a trap-door incision, four by three-quarters inches, was made into the bone. The periosteum was roughened and a gritty, grayish material was removed from the marrow cavity. The diagnosis, as above stated, was unclassified sarcoma. The symptoms recurred within six

FIG. 12

Case 10. Three months after the beginning of x-ray treatment, showing decided improvement.

FIG. 13

Case 10. After ten months of x-ray treatment, showing relapse with extensive new growth.

months and the bone showed osteoclastic changes. A second exploration was made, with no more definite conclusions. Relief was secured by radiation. There was no recurrence of the local symptoms. The patient died four years later from metastasis. The roentgenogram demonstrated involvement of the fifth lumbar vertebra, which gave a similar appearance to the tumor in the tibia. Autopsy was permitted, but was performed only on the lumbar spine. The vertebra showed extensive destruction with a grayish-white tumor surrounding the bone. The microscopic examination by Dr. J. F. Hamilton was suggestive of Ewing's tumor, and material has again been submitted to the Registry.

The second case of unclassified sarcoma, R. G., a boy aged nine years, gave a history of sudden onset thirteen months previously, following trauma. At the end of two weeks a large quantity of pus was evacuated and a sinus continued. On exploration by my colleague, Dr. J. S. Speed, a pale, oedematous, neoplastic-like tissue, with marked destruction of the ilium, was found. There was decided local recession in the tumor following x-ray treatment, and the wounds have healed.

The third case of unclassified sarcoma, H. M., was a man aged forty-five years. Ten weeks previously he had a sudden onset of severe pain in the left hip, but there was no elevation of temperature. An incision was made over the external aspect of the joint without results. The wound healed. Our examination revealed an indurated mass over the left hip. The roentgenogram showed extensive destruction of the left acetabulum, the ilium, and the head of the femur. At operation extensive destructive changes in the left hip joint were found, no pus, but necrotic tissue resembling Ewing's tumor. X-ray treatment gave immediate relief with recession of the process, though a draining sinus persists.

The clinical course and the fact that the process extended across the joint in so short a time, are not regarded as consistent with Ewing's tumor or any other type of malignancy.

There were three cases in which the diagnosis was osteomyelitis, but in each there was some element of the roentgenographic or clinical course that led us to suspect the possibility of endothelial myeloma. The Registry classified all three as inflammatory, though some difference of opinion existed. The subsequent course has proved the diagnosis correct. A history of one case will illustrate.

Mrs. Q. was a woman, aged thirty-four. Six months prior to admission there appeared a brawny mass on the anterior and external aspects of the left forearm, which gradually increased in size. Pain was worse at night. The Wassermann test was negative. The roentgenogram showed thickening of the cortex of the middle third of the left radius, with a small cavity. Intensive antiluetic treatment was given without improvement. At operation the bone cavity and marrow cavity were cleaned out; the appearance was that of a low-grade osteomyelitis. Microscopic examination revealed chronic inflammatory tissue. The symptoms did not improve after operation and the brawny inflammatory-like mass increased at intervals. Tissue was submitted to the Registry and others for opinions. The final course proved the condition to be inflammatory.

These three cases and the group described as unclassified sarcoma illustrate the similarity between inflammatory lesions and endothelial myeloma,—clinically, microscopically, and roentgenographically.

Undoubtedly autopsies would be of material value and would probably add much to our knowledge of the subject. Unfortunately, only one complete autopsy and a partial one were performed in these cases. A

majority of patients with such affections return home before death ensues, and are not, therefore, available for this purpose.

The symptom of intermittent pain with swelling is by no means limited to Ewing's tumor. I have seen very similar symptoms as a result of syphilis, osteomyelitis of Garrè, subacute and low-grade osteomyelitis, and osteogenic sarcoma. The differentiation of syphilis is made by the Wassermann test, and the bone changes, as demonstrated by the roentgenogram, are usually different. Only in the osteomyelitic type of syphilis should there be any confusion. In osteomyelitis of Garrè there is often a history of a sudden onset with a slight elevation of temperature, but no recurrent attacks, the symptoms being more or less continuous; when remittent there is no sudden increase of swelling or elevation of temperature. Moreover, in osteomyelitis of Garrè the process as demonstrated by exploration and by roentgenogram is predominantly productive. There is condensation with spindle-shape enlargement and proliferation of the periosteum. In the first stage of Ewing's tumor there is condensation, but no expansion. In the second stage there is proliferation of the periosteum, but with destructive changes in the shaft. The suggestion has been made that osteomyelitis of Garrè is Ewing's tumor in which healing by nature has occurred, but no evidence to substantiate such a statement has ever been advanced.

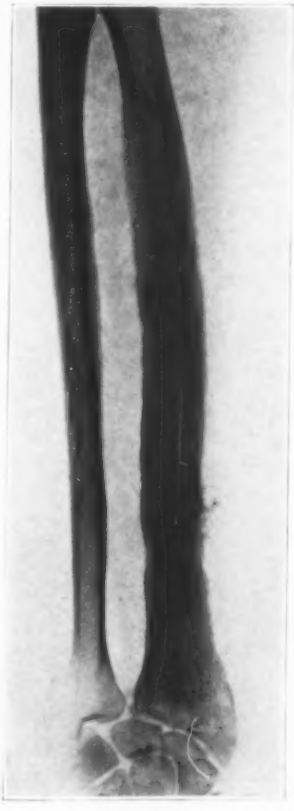

FIG. 14

Case Miss R. B. Syphilis giving every classical symptom of Ewing's tumor. Cured by usual treatment.

In acute infectious osteomyelitis, the onset is sudden with no previous local symptoms, the temperature is high with a marked increase in total white cells and in polymorphonuclear neutrophiles. At the onset and in the early stages of Ewing's tumor the temperature is usually about 99 to 100 degrees, and as the process advances the temperature increases to about 100 to 101 degrees, but in exceptional instances may be much higher,—103 to 104 degrees. There is usually only moderate or no increase in the total white-cell count, and the differential count is usually about normal, unless there is secondary infection. Errors in diagnosis are not usually made during the initial attack, but in subsequent attacks when the symptoms more closely resemble osteomyelitis. An accurate history is one of the most important differential factors between osteomyelitis and Ewing's tumor. In acute pyogenic osteomyelitis, the roentgenogram is always negative at the time of onset, and for two or more

weeks thereafter. In Ewing's tumor there are always definite structural changes in the bone by the time symptoms are apparent. Routine microscopic examination of tissue removed will usually demonstrate a tumor if present, while culture in Ewing's tumor is negative, but in osteomyelitis positive for some pyogenic organism. In Ewing's tumor, in which there has been an open operation with infection and a draining sinus, differentiation is often very difficult. If from the history, roentgenogram, or tissue examination there is reason to suspect Ewing's tumor, x-ray treatment will help to differentiate, since it will cause a rapid recession in Ewing's tumor, while in osteomyelitis it will have no appreciable effect. In the subacute stage of osteomyelitis the roentgenogram may very closely resemble that of Ewing's tumor, especially in those cases where there has been extensive destruction without bone production. The roentgenographic appearance may be almost identical when there is involvement of cavernous bone, as in the upper extremity of the femur and the ilium. There is seldom occasion for error in diagnosis when the lesion is in the shaft of one of the long bones. When definite sequestration is apparent, the process is almost always osteomyelitis. In the second stage of Ewing's tumor in the shaft of the long bones the changes are almost conclusive, but in the third stage the periosteum is destroyed over a large area with marked lipping at the junction of the normal shaft and the tumor. In osteomyelitis the periosteum is very irregular, but intact except for small fenestra which have been punctured by the pressure of the purulent exudate. No material that is identical with pus is found on exploration of a Ewing's tumor, but when any material is found it is thinner than pus in consistency and is often tinged with pigmented necrotic material. Rarely is there any substance resembling the thick, creamy pus of a typical osteomyelitis, unless there is a secondary infection.

Osteogenic sarcoma can usually be differentiated by the history and the roentgenogram, for in osteogenic sarcoma the shaft is intact through the tumor; there is often bone production a considerable distance from the shaft, but it is within the tumor. Bone is more frequently produced beneath the periosteum at right angles to the shaft. In both conditions there is lipping, but this is much more marked in Ewing's tumor. The only type of osteogenic sarcoma that closely resembles Ewing's tumor is the rapidly-growing, osteolytic type, which is often largely composed of undifferentiated osteogenic cells. There is destruction of the entire bone, which may closely resemble Ewing's tumor in the third stage after disintegration of the reactive bone layers of the periosteum has taken place. As in osteomyelitis, the roentgenogram and radium irradiation will differentiate, as osteogenic sarcoma does not respond to irradiation.

Hirsch and Ryerson have conclusively proved that there is a close resemblance to metastatic carcinoma, as demonstrated in the case of a boy, aged six, with primary carcinoma in the bronchi. A similar error has probably been made also in Case 6 of our series, as above mentioned. Possibly this condition may occur more frequently than is generally recognized.

The chaotic status that previously existed regarding bone tumors has been materially improved by the Registry of Bone Sarcoma, and in a majority of cases the diagnosis can be made unquestionably. However, there still remain many cases in which there is a difference of opinion, and it is not infrequent that a change in diagnosis is made on investigation of a case. In Ewing's tumor and osteogenic sarcoma there has undoubtedly been a definite reduction of the mortality since the establishment of the Registry of Bone Sarcoma by the American College of Surgeons. Contrast the two tables of Ewing's tumors: in Table I, out of eleven cases registered, there are three living and healthy, three, four, and seven years respectively. In the cases of Ewing's tumor shown in Table II, practically no treatment was given; five have died, and in the other, Case 17, a recent case, with involvement of the seventh rib, the parents of the patient have declined treatment and the results are inevitable.

As the results in malignant bone tumors are far from satisfactory, any form of treatment that offers the slightest aid deserves consideration. Ewing's tumor, clinically, microscopically, and roentgenographically, very closely resembles inflammatory lesions; therefore foreign protein, as is found in Coley's toxins, is at least worthy of trial. However, I desire to clearly emphasize that, at the present time, I make no claim, pro or con, as to the beneficial effect of this agent.

CONCLUSIONS

In conclusion, the following points should be emphasized:

1. Endothelial myeloma is a definite clinical entity and is probably of more frequent occurrence than is generally recognized. Many patients dying of prolonged sepsis from osteomyelitis are probably suffering from this tumor.

2. There is much difference of opinion as to the true nature of the tumor, and, until further proof is submitted, all theories should be considered.

3. The correct diagnosis can be made, with very rare exceptions, if due regard is given to an accurate history and other clinical tests. Erroneous operations for osteomyelitis are almost always performed after the occurrence of remittent attacks, and not in the initial attack.

4. There are three distinct and definite stages, as demonstrated by the roentgenogram, the knowledge of which should materially aid in diagnosis.

5. Radium and x-ray irradiation are the only known remedies that have a definite beneficial action on the evolutionary process; therefore, they should be employed in every case, before and after, or without radical operation. The tumor responds to both radium and x-ray, but the latter is of more value as it is more generally accessible. Irradiation as a diagnostic agent also is most valuable and should be more generally employed. The value of foreign-body protein, as Coley's toxins, is yet to be determined.

6. The mortality remains high, but has been reduced to some extent by utilizing more effectively our knowledge of the subject, for which gratitude should be expressed to the Registry of Bone Sarcoma.

7. Amputation or radical excision, preceded and followed by irradiation locally and to the chest, is apparently the treatment of choice. However, evidence as to the manner of treatment in the varying degrees of malignancy, and as regards age and location, is necessary before definite conclusions can be reached.

8. No effort has been made to discuss in detail the histogenesis or differential microscopic findings in bone tumors, as this would require one trained in this special field. The main objective of this paper is an analysis from a practical point of view of the salient features in a fairly large group of endothelial myelomata.

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COXA PLANA AND RELATED CONDITIONS AT THE HIP

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PART I

CLASSIFICATION AND CORRELATION OF THESE CONDITIONS

Part I of this study of coxa plana and the related conditions of the hip joint is written for the purpose of classifying and correlating these conditions and their variations. Slipping of the upper femoral epiphysis, osteochondritis dissecans, a certain group of cases of chronic degenerative arthritis, and a condition not previously identified as a clinical entity, to which the name coxa magna is given, are included. Subsequent reports will present the clinical, pathological, and roentgenographic evidence which leads to this classification and to the conclusion that all of these conditions, including coxa plana, result from a circulatory disturbance in or adjacent to the femoral head. For convenience, this circulatory disturbance will hereafter be designated as ischaemia.

The conditions referred to above are not primary diseases, but are the effect of the underlying ischaemia. The cause and distribution of the ischaemia may vary. The condition resulting from the ischaemia is determined by the age of the patient, the distribution and degree of ischaemia, and, to a slight extent, by sex and some minor factors.

TYPES OF ISCHAEMIA

In our cases of coxa plana and related conditions ischaemia has been found to arise from several causes classified and described as follows:

Type 1. Inflammation in the hip joint.
Type 2. Inflammation or, rarely, tumor adjacent to the joint, usually in the femoral neck.
Type 3. Fracture or epiphyseal separation at the femoral neck.
Type 4. Trauma to the femoral head.
Type 5. Tension of the soft tissues about the femoral neck.

Type 1:

A subacute infectious arthritis at the hip, which may be too mild to cause the patient to seek treatment, may be followed first by congestion and later by sclerosis of the capsule, synovial membrane, and tissues about the femoral neck. These changes have often been demonstrated at operation and in microscopic examinations in early cases of coxa plana and related conditions. When these changes have occurred the flow of blood

to and from the femoral head is disturbed, resulting in ischaemia * from which coxa plana or a related condition may develop.

About seventy-five per cent. of the cases in this category had had some infection—usually diseased tonsils—not long before the onset of symptoms of coxa plana or a related condition at the hip. Unusual infections elsewhere in the body may be followed by unusual manifestations at the hip. For example, a patient who had had spinal meningitis six months before the onset of coxa plana at the hip had an unusually stiff hip with thinning of the cartilaginous joint space (unusual in coxa plana).

Suppurative arthritis of the hip has not resulted in conditions of the coxa-plana group except in rare cases drained so early that healing was complete except for the residual sclerosis of the soft tissues about the femoral neck.

Type 2:

Infection in the femoral neck, in the ilium, or in the thigh or buttock adjacent to the hip may result in sclerosis of the tissues about the femoral neck, producing ischaemia of the head, as in Type 1. A tumor of the femoral neck may have the same effect; we have seen one case of osteitis fibrosa in the femoral neck with coxa plana. This group is differentiated from the Type 1 ischaemias because the concurrent presence of a lesion adjacent to the hip complicates the treatment of the coxa plana or related condition.

Type 3:

Fracture of the femoral neck or traumatic epiphyseal separation causes partial or complete disruption of the circulation of the femoral head. Usually circulation is so promptly and completely reestablished after these accidents that coxa plana does not develop. In some cases, however, the reestablished circulation may be insufficient, and coxa plana may follow. If there is no reestablishment of circulation, the separated part remains as an inert dense body in which coxa plana does not develop. Insufficiency of the circulation may result from delayed union, pressure, or tension upon the soft tissues about the femoral neck. The latter appears to be related to the position of immobilization, the amount of hemorrhage, and the previous condition of the tissues about the femoral neck (see Type 5).

Type 4:

A. Traumatism to the femoral head by a sudden sharp blow may produce a plane of petechial hemorrhages in the head, demarcating a

* It is not known whether subsequent changes in the bone, such as those of coxa plana, should be attributed to a disturbance of flow of lymph rather than of blood. The word ischaemia is used as a general designation for the whole of the circulatory disturbance in all of its phases produced by the cause described here and demonstrated at operation in these cases. In some cases the bone is found to be avascular, in others passive congestion is present. These are probably different stages in the development of the circulatory disturbance.

plaque of bone at the surface,—an osteochondritis dissecans.* The hemorrhage and subsequent fibrosis in the plane of hemorrhage produce ischaemia and irregular absorption or extrusion of the demarcated plaque of bone. Ordinarily no fracture is demonstrable roentgenographically in these cases, but a demonstrable fracture of the femoral head may occasionally be followed by a similar result.

B. Ischaemia is produced and bone absorption may result if a portion of the circumference of the femoral head is removed surgically, particularly if more than one-third of the circumference is removed, as is often the case in reconstruction operations. This absorption is irregular and is often identical with the irregular ossification of other types of coxa plana. When the crest of the femoral head is removed surgically, there may be irregular absorption of the remainder of the head, which differs from the irregular ossification in coxa plana only in that it is at the surface of the bone instead of beneath the cortex. As the absorption is due to ischaemia, it is regarded as a condition related to coxa plana.

Type 5:

Tension of the soft tissues about the femoral neck may interfere with circulation to the femoral head sufficiently to produce an effective ischaemia,—that is, an ischaemia capable of resulting in coxa plana or a related condition. Such tension appears to occur particularly on immobilization in a position of forced rotation and abduction, as in reduced congenital dislocation of the hip, but may be aggravated by other factors, such as hemorrhage in the joint or previous sclerotic changes in the tissues about the femoral neck. Such tension may also be a factor in the production of ischaemia following trauma to the femoral head or neck (Type 3 and Type 4), but a separate group (Type 5) is made of these cases with soft-tissue tension without evident trauma because the treatment and course in this group are not complicated by the presence of a traumatic lesion of the bone.

VULNERABILITY

Ischaemia at the femoral head may result from any one of the several causes that have been described, and may cause one of the conditions related to coxa plana in one patient, a different condition in another patient, and no sequela at all in a third patient, depending chiefly upon the age and sex of the patient and the degree of ischaemia. In the first decade of life, the substance of the femoral head is more susceptible to the influence of a circulatory disturbance; in adolescence, the growth disc is more likely to be affected. We may express this by saying that in one instance

* It is generally accepted that this occurs, but we have not had the opportunity to prove it in osteochondritis dissecans at the hip. Also one of the theories that has been advanced concerning coxa plana is that it may be due to the effect of petechial hemorrhages widely distributed through the femoral head after trauma. We cannot disprove this and it is theoretically possible. It may, therefore, be a cause of some cases of coxa plana, although we have not yet seen a case which did not seem to be due to one of the other types of ischaemia described in this paper.

the head is vulnerable; in the other instance, the growth disc. In an age period at which the growth disc is vulnerable to the presence of a moderate degree of ischaemia, the substance of the head may be vulnerable to a greater degree of ischaemia; whereas neither may be vulnerable to a lesser degree of ischaemia. Vulnerability of a given part of the hip occurs some two or three years earlier in life in girls than in boys. The relationship between vulnerability of the part and the type, degree, and distribution of the ischaemia determines whether coxa plana or a different but related condition shall develop. As the course, prognosis, and treatment of these conditions may vary with the disturbance giving rise to the ischaemia, it is necessary to differentiate the cases of each condition according to the type of ischaemia present. Coxa plana, for example, might follow the ischaemia produced by subacute infectious arthritis or that produced by tension of the soft tissues about the femoral neck, and the course, prognosis, and treatment would be quite different in the two cases.

SEQUELAE OF INFLAMMATION IN THE HIP JOINT

Type 1 ischaemia may cause coxa plana, slipping epiphysis, coxa magna, or degenerative arthritis.

Coxa Plana—Type 1 Ischaemia:

This is the most common type of coxa plana. The approximate age period is from three to twelve years.* The substance of the head rather than the growth disc is vulnerable at this period, especially from the ages of three to ten years, and particularly in males. Some of the vessels of the femoral head may be more affected by sclerosis about the femoral neck than others and the distribution of the changes of coxa plana in the head is believed to be related to the distribution and degree of circulatory impairment. Coxa plana of this type is the subject of Part II of this study, which follows.

Slipping of the Upper Femoral Epiphysis—Type 1 Ischaemia:

This is the common type of slipping epiphysis. A study of seventy cases of this kind has been reported by the authors[1]. The preslipping stage in boys occurs in the age period from nine to sixteen years; in girls, from eight to thirteen years. Between the ages of eight and twelve, there is a transition from vulnerability of the head to vulnerability of the growth disc. Early cases of Type 1 ischaemia in the latter age period may be indeterminate as to whether they will develop coxa plana or slipping epiphysis,† and some cases may subside without definitely developing either. In the age period from thirteen to seventeen years in boys and ten to fourteen years in girls, the growth disc is even more vulnerable and slipping of the epiphysis occurs.

* Age periods refer to the age at onset of symptoms.

† Coxa plana is rare in females and preslipping epiphysis in males in the age period rom eight to ten years.

Coxa Magna—Type 1 Ischaemia:

The approximate age period for this affection is from four to fifteen years. There are cases in which Type 1 ischaemia is present subsequent to subacute arthritis, but with the degree of impairment not sufficiently great, or the part not sufficiently vulnerable, to result in coxa plana or slipping epiphysis. Such cases have the clinical picture of coxa plana, but the roentgenographic findings are those of a growth disturbance,—namely, elongation of the femoral neck, broadening of the head and neck, and premature ossification of the growth disc of the femoral head and greater trochanter. The capsule at the hip joint is prominent laterally and some decalcification may be present. These cases are designated as coxa magna. It is important to recognize these cases because when they are diagnosed as tuberculosis, acute arthritis, or chronic rheumatoid arthritis they are subjected to treatment that they do not need.

Occasionally in mild cases of coxa plana or slipping epiphysis there is elongation of the femoral neck with broad, well formed head and neck. This may be regarded as a coxa magna manifestation in these related conditions, especially when overdevelopment continues after the mild primary condition has subsided.

Chronic Arthritis—Type 1 Ischaemia:

When subacute infectious arthritis occurs in a patient who has passed the age at which slipping epiphysis or coxa magna can take place and resolves into sclerosis of the tissues at the joint, these changes have no direct effect on the bone,—the bone is no longer vulnerable. The sclerosed tissues and poor circulation are an excellent foundation for degenerative changes, and the calcareous lipping of chronic degenerative arthritis develops. Many cases of monarthritis in young patients and some cases in older patients belong in this group.

The same tendency to degenerative arthritis is present in other Type 1 ischaemias (slipping epiphysis and coxa magna) as the patients grow older. However, when the ischaemia develops early in life, as in most instances of coxa plana, there is time for the tissues to regain a comparatively healthy state before the age at which degenerative changes would be likely to occur and, accordingly, degenerative arthritis is not such a common sequela. All of our patients with slipping epiphysis who have reached the age of seventeen have developed degenerative arthritis; whereas only half of the patients with coxa plana have arthritic changes at that age.

SEQUELAE OF INFLAMMATION ADJACENT TO THE HIP

Type 2 ischaemia may cause coxa plana, slipping epiphysis, coxa magna, or chronic arthritis.

Coxa Plana and Slipping Epiphysis—Type 2 Ischaemia:

The approximate age period for coxa plana is from five to ten years; that for slipping epiphysis, from ten to sixteen years. These two condi-

tions are completely analogous to the corresponding Type 1 ischaemias except that the course, prognosis, and treatment are influenced by the simultaneous presence of a lesion in the neck of the femur or adjacent to the hip.

Coxa Magna—Type 2 Ischaemia:

Overgrowth of the head and neck—as in coxa magna, Type 1 ischaemia—occurs with lesions in the neck or adjacent to the hip, but is of minor importance as compared to the adjacent lesion. However, the overdevelopment may continue after the adjacent lesion has been cured, and such cases must then be recognized and treated as coxa magna.

Degenerative Arthritis—Type 2 Ischaemia:

When a lesion adjacent to the hip has produced sclerosis of the tissues about the femoral neck, the ischaemia may not result in coxa plana, slipping epiphysis, or coxa magna if the part is not at a vulnerable age or if the ischaemia is mild. Such cases may be followed by chronic degenerative arthritis, as in Type 1 ischaemia. The lesion adjacent to the hip has usually healed by the time degenerative arthritis develops.

SEQUELAE OF EXTRACAPITAL TRAUMATISM

Type 3 ischaemia may cause coxa plana and possibly coxa magna. We have not seen slipping epiphysis as a sequela to a known fracture of the femoral neck; one case gave such a history, but it was unconfirmed.

Coxa Plana—Type 3 Ischaemia:

A. We have a group of eight cases of slipping epiphysis, Type 1 ischaemia, in which reduction was obtained by strong traction, causing temporary but probably complete separation of the femoral head and considerable hemorrhage within the joint. The patients were immobilized in the position of forced abduction and internal rotation. Before reduction had been obtained, these patients had the Type 1 ischaemia which produced the slipping epiphysis. To this the Type 3 ischaemia was added by the reduction and immobilization. In fifty per cent. of these cases marked changes of coxa plana in the femoral head developed. The ischaemia producing the coxa plana is believed to have been contributed to by: (1) the sclerosed condition of the tissues about the femoral neck, which caused the slipping epiphysis; (2) marked hemorrhage confined within the joint; (3) tension about the femoral neck, developed by the position of immobilization (see Type 5 ischaemia); (4) temporary separation of the femoral head. The result of the manipulation was a degree of ischaemia sufficient to produce coxa plana, even though the substance of the head is not ordinarily vulnerable at the age period when slipping of the epiphysis usually occurs.

B. We have two cases of ununited fracture of the neck of the femur in the aged, which were united by means of small bone chips implanted be-

tween the freshened fracture surfaces, and which subsequently developed the changes of coxa plana in the femoral head. The reestablishment of circulation to the femoral head through the layer of chips is slow and, for a long time, insufficient. This period of insufficiency constitutes a type and degree of ischaemia of the femoral head sufficient to produce coxa plana even in mature bone which is not ordinarily vulnerable.

C. In rare instances, coxa-plana changes in the femoral head are found after fracture of the femoral neck. The patients are usually adolescent, but they may be younger or older. An example of this is a case of congenital dislocation of the hip in which the femoral neck was fractured upon attempted reduction. Tension about the femoral neck, produced by rotation or abduction, is very probably a factor in determining whether or not a given case of fracture of the neck will develop the ischaemia which will produce coxa plana. In that respect these cases resemble Type 5 ischaemia. The designation, Type 5 ischaemia, is reserved, however, for those cases which are not complicated by definite extracapital traumatism.

SEQUELAE OF TRAUMA TO THE FEMORAL HEAD

Type 4 ischaemia may cause coxa plana or osteochondritis dissecans.

Coxa Plana—Type 4 Ischaemia:

Surgical interference with the circumference of the femoral head (as in the removal of osteophytes or protuberances) may result in an ischaemia of the head sufficient to produce coxa plana or irregular absorption of the head, particularly if more than one-third of the circumference is removed. The irregular absorption is more nearly identical to other types of coxa plana when the patient is young.

Coxa plana might also occur after trauma of the femoral head from a sharp blow, but we have not yet seen a case which we believed was due to this cause.

Osteochondritis Dissecans—Type 4 Ischaemia:

The age period is from late adolescence to adult life, rarely earlier. This is the usual osteochondritis dissecans. It follows trauma of the femoral head caused by a sharp blow. An intracapital traumatism in younger children would probably result in coxa plana, Type 4 ischaemia, if anything.

Usually there is no fracture detectable roentgenographically at the onset of osteochondritis dissecans, but we have observed one case, that of an adolescent male who did have a fracture. In this case, there were two lines of fracture through the femoral head; both were sagittal and extended from the crest to the epiphyseal line. The middle third of the head was thus demarcated from the inner and outer thirds. This patient developed typical osteochondritis dissecans of the whole middle fragment of the head.

It should be noted that in coxa plana (ischaemia Types 1, 2, and 3) the distribution of irregular ossification may be such that a portion of bone at the crest of the femoral head may appear to be separated from the rest of the head. Such a condition may properly be referred to as an osteochondritis-dissecans type of coxa plana, although we have no instance of the development of a loose body in this manner, possibly because of the relative thickness of the cartilage at the femoral head in children. It is possible to arrange a series of roentgenograms of gradations from typical coxa plana to typical osteochondritis dissecans in such a manner that a definite division cannot be made between the two. The borderline cases form an indeterminate group between the two conditions.

SEQUELAE OF TENSION ABOUT THE FEMORAL NECK

Type 5 ischaemia may cause coxa plana and may be a contributing factor in Type 3 ischaemia or an additional factor, aided by the method of treatment and immobilization, in conditions arising from other types of ischaemia.

Coxa Plana—Type 5 Ischaemia:

The approximate age period is from one to six years. This condition occurs chiefly in cases of congenital dislocation of the hip in which open or closed reduction has been attempted or obtained. In our cases care in avoiding trauma to the femoral head during the manipulation had no effect on the incidence of coxa plana. Also, the incidence was as great after open reductions where the head was not traumatized as after closed manipulations. The incidence was not affected by cutting the ligamentum teres. We have not noted coxa plana after unsuccessful closed reductions when the hip was not immobilized, although these manipulations traumatized the head as much as the successful procedures. These facts are evidence that coxa plana in congenital dislocation of the hip is not due to trauma to the femoral head. We believe that the ischaemia producing the coxa plana is the result of tension of tissues about the femoral neck. This tension appears to be associated with rotation or abduction to obtain the position of immobilization, although hemorrhage in the joint and the newly acquired position of reduction may be contributing factors.

We have seen one case of late coxa plana in which a fusion operation was performed at the hip at the age of eight because of stiffness and disability. The hips were immobilized in a double spica in the position of abduction. In four months the supposedly sound hip began to develop typical coxa plana, but this condition promptly cleared up on removal of the plaster spica. We consider this a coxa plana due to Type 5 ischaemia.

Coxa plana of this type has a great potential of recovery, even without treatment. There is nothing essentially abnormal in the cellular structure of the tissues about the femoral neck. The tissues under tension grow, relieving the tension; the hemorrhage is absorbed; and immobilization is maintained for only a few months. Tension about the femoral

neck is, therefore, soon relieved: circulation to the femoral head improves; and the coxa plana heals spontaneously.

Congenital dislocation of the hip is uncommon in males. Coxa plana is uncommon in females except in congenital dislocation of the hip. These facts seem to be an expression of the relative vulnerability of the hip in males and females,—vulnerability occurring in the male some years later than in the female.

MISCELLANEOUS CONDITIONS

1. Subacute arthritis may occur and subside without a sequela in cases where the degree of involvement is slight or the hip is not vulnerable. In such cases there are symptoms and signs for a short time which suggest the onset of coxa plana, but these clear up without further changes. The cases are classed as abortive if coxa plana or preslipping epiphysis actually develops but resolves after slight changes occur.

2. Broad, shallow, and sometimes irregular femoral heads occur in some forms of chondrodystrophy. These are not to be confused with coxa plana, which is characterized chiefly by irregular ossification of the head and by symptoms and signs of inflammation which are not present in chondrodystrophy unless complicated by actual coxa plana or a related condition.

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Part II

A Study of Seventy-five Cases of Coxa Plana

A condition of the hip occurring between the ages of three and twelve years is variously described in the literature as coxa plana, Legg's, Perthes', or Calvé's disease, osteochondritis deformans juvenilis, pseudocoxalgia, and aseptic necrosis of the upper femoral epiphysis. It is a condition characterized roentgenographically by flattening of the crest of the upper femoral epiphysis, with widening of the joint space and alterations in the density and evenness of ossification of the epiphysis and the proximal end of the femoral neck.

We are presenting a study of seventy-five cases of this condition (eighty-three hips) from the New York Orthopaedic Dispensary and Hospital. These hips are classed as coxa plana following subacute arthritis,—the Type 1 ischaemia described in Part I of this study. No hips with congenital dislocation, tuberculosis, or other specific infection, or transitional between coxa plana and slipping epiphysis are included in this report; such hips are being studied separately.

Sixty-three patients (sixty-nine hips) were seen during the progress of the disease; twelve patients (fourteen hips) were not seen until after repair had developed (these patients ranged in age from twelve to thirty-two years, with the exception of one patient who was seven and one-half years of age). Sixty-four patients (85 per cent.) were males; eleven were females. The left hip only was affected in thirty-six instances, the right in thirty-one, and in eight cases both hips were involved. Bilateralism in coxa plana is about as frequent as in slipping of the upper femoral epiphysis, and little more common than in frank infections; thus the cause of coxa plana does not appear to be a general disturbance, such as an endocrine disorder, which should result in a higher bilateral incidence.

About equal numbers of patients were tall or of average stature, thin or obese. Only three obese patients appeared to be of the Mikulicz type (large, flabby, with weak musculature). There appears to be no definite association of type of stature or pituitary-gonad disturbance with this type of coxa plana.

Of the similar disturbances (osteochondrosis) in other bones, Köhler's disease of the tarsal navicular bone and apophysitis of the calcaneum were each present in one case. However, roentgenograms of other bones were made only when they presented clinical evidences of disease.

Diseased tonsils were noted at, or shortly before, the onset of coxa plana in twenty-six (46 per cent.) of fifty-six patients who had a tonsil record; and four patients had other infections. An additional thirty-three per cent. had had an infection several months before the onset of coxa plana. These facts suggest the possibility of infection as an etiological factor.

CHARACTERISTICS OF ONSET

The age at the onset of symptoms in the hip varied between three and twelve years, the average age being seven years. The onset was between the ages of six and ten years in sixty-one per cent. and between three and six years in twenty-six per cent., a total of eighty-seven per cent. between the ages of three and ten years. In only three instances the onset occurred after the age of ten years in the cases seen before the residual stage. Two children, seen at the age of four years, had hip symptoms at one year, but it appears likely from the histories and roentgenograms that coxa plana was not present before the age of three. Of the thirty-five cases in which the fact was recorded, the onset was sudden in twenty-two (63 per cent.), gradual in thirteen (37 per cent.). Trauma to the hip within three months of onset occurred in twenty-two (45 per cent.) of the forty-eight hips of which a record was made. In thirteen (58 per cent.) of these twenty-two hips the onset was sudden; in three, gradual; and in six cases there was no record. The trauma was usually trivial and sometimes the roentgenographic evidence indicated that the condition must have begun before the trauma.

There was no seasonal incidence of the onset among boys, but the onset of the symptoms in the eleven girls occurred between February and

July. There was no other important difference in the features of the onset between the boys and the girls.

The predominating symptoms recalled by the patients in regard to the onset were limping and pain, each being present in more than half of the cases and both being present in nearly half. Limitation of motion was noticed by one-fourth of the patients. Disability of any consequence was uncommon.

STAGES OF COXA PLANA

The course of coxa plana may be divided into three stages: active, reparative, and residual. The onset and development of these stages usually do not coincide clinically, pathologically, and roentgenographically; each stage generally begins and ends later in the bone than in the soft tissues (synovial membrane, etc.).

CLINICAL COURSE

The active stage clinically is associated with soft-tissue inflammation—which is evidenced by pain and limitation of motion—and roentgenographically demonstrable soft-tissue swelling, which are often present before changes in the bone are demonstrable roentgenographically or pathologically. In our cases in the active stage there was limping or pain, or both, and occasionally disability and stiffness. Careful examination demonstrated that all motions were limited at least slightly in all directions, except in a few early cases in which there were no symptoms. This is contrary to other reports which have stated that usually only abduction and rotation are limited. Adduction was often more limited than abduction. Flexion was less frequently and less markedly affected than lateral and rotary motion. The index of motion* was rarely less than 50 and the average was 67, that of the normal hip being 90 to 110. In a few instances, the hip was almost rigid, with spasm and pain. Shortening of the leg was not present in the active stage, but atrophy of the thigh, averaging one inch, was usual. Spasm and limping were nearly always found; tenderness and pain, especially at the extremes of motion, were common.

The reparative stage clinically is associated with soft-tissue healing and scarring, evidenced by lessening of pain and spasm and increase in the range of motion. Its termination is marked by the absence of pain and spasm. Ordinarily the reparative stage is completed clinically months or years earlier than roentgenographically. In our cases in the reparative stage, the pain, disability, spasm, tenderness, and limping gradually disappeared; motion usually improved slowly, but sometimes it became more limited and slight shortening (average, two-fifths of an inch) developed.

The residual stage clinically is marked by the absence of spasm. It precedes by some months or years the roentgenographic and pathologi-

*The index of motion used here is described by the authors in "Slipping of the Upper Femoral Epiphysis" (J. Am. Med. Assn., XCVII, 1867, 1931).

cal residual stages which are marked by the completion of repair in the affected bone. In this stage, limping was present in about one-third of the cases; pain, on forced motion and on activity, in half. Only one hip had normal motion in all directions; the average hip had about two-thirds of the normal motion. Shortening and atrophy usually persisted. In many instances, the patients were unable to take part in strenuous exercise, such as athletics.

PATHOLOGY

An exposure of twenty-one hips (eighteen patients) was made at operation. Six of the hips were exposed early in the active stage, two early in the stage of repair, and the others later in the same stage.

In the active stage, the synovial membrane was always thickened, soft, fragile, very vascular, and often irregular, with villus formation. The periosteum was usually thickened and oedematous. The capsule was usually thickened, slightly oedematous, and more vascular than normal. The contour and appearance of the visible portion of the cartilage of the femoral head were normal. The synovial fluid was not abnormal. On microscopic examination, the synovial membrane was usually oedematous, contained clusters of lymphocytes, and was often villous; the capsule and periosteum were chronically inflamed in most cases.

In the earliest cases the presence of extensive changes in the synovial membrane, capsule, and periosteum before the contour of the head had become abnormal indicates that these changes are not secondary to trauma caused by a deformed head, but are primary. They apparently are the result of previous synovitis or arthritis, probably infectious, and they appear to be the cause of the subsequent changes within the epiphysis through the medium of the circulatory disturbance which they produce,—the Type 1 ischaemia described in Part I of this study.

In the hips exposed in the reparative stage, the synovial membrane was smooth, inelastic, tough, thin, ivory-colored, and avascular. The periosteum and capsule were scarred and inelastic. The cartilage of the femoral head was flattened in only four instances, but, in several, it had proliferated at the margin, with development of a pannus. The cartilage was otherwise normal in appearance in all hips, as far as it could be seen without dislocating the hip. On microscopic examination, the soft tissues were extensively scarred and contained thick-walled vessels of small lumen; in several instances, evidence of degeneration was present in the cartilage from the margin of the head.

Pathological changes in the bone of the femoral head were not synchronous with changes in the soft tissues. The earliest cases showed no definite abnormality in the bone. In later cases, the bone of the head, as felt with the drilling instruments, usually seemed normal in density. However, in several cases very dense bone was encountered, and in other cases certain portions were soft; these areas apparently represented a later stage in the disease. The bone of the femoral neck was usually of

normal texture and density. No distinction between cap or mushroom type could be made on inspection of the femoral head. The deformity of the bone demonstrable roentgenographically and visible externally in some of the later cases, and originally described as the characteristic feature of the disease, is evidently the late result of the softening of the epiphysis, because of the circulatory disturbance and the proliferation of cartilage and bone in the process of healing.

On microscopic examination, the bone of the head and of the neck was usually normal, but, in several instances, marginal absorption was seen.

In no case operated upon has there been any postoperative reaction of a type which would suggest that an infectious process had been activated by the operation; nor have any alterations occurred in the roentgenographic appearance of the bones which would in any way suggest the presence of infection. This is strong evidence that coxa plana is not due to the presence of infection in the bone, and it is perfectly compatible with the theory that coxa plana is the result of a circulatory disturbance which is due to sclerotic changes in the soft tissues at the hip subsequent to previous infectious arthritis or synovitis.

Cultures from four hips and anaerobic cultures from two hips resulted in no growth. Guinea-pig inoculations in two cases were negative for tuberculosis. The Mantoux or von Pirquet test was done in twenty-five cases. The results were positive in six cases, doubtful in two, and negative in seventeen. Blood Wassermann tests were done in twenty-six cases. In one case, the reaction was four plus; in the others, it was negative. The red-blood-cell count (done in fifteen cases) varied with a fairly even distribution between 3,500,000 and 5,000,000. The hemoglobin varied between sixty and ninety per cent., the average being seventy-four per cent. The white-blood-cell count (done in twenty-one cases) varied between 7,000 and 15,000; in two-thirds of the cases it was above 10,000. The polymorphonuclear leukocytes varied between forty-four and ninety-six per cent.; in one case only were they above eighty per cent., and in sixteen cases below seventy per cent. Urine examination for albumin and sugar was negative; microscopic examination was also negative. The sedimentation rate was tested in three cases in the reparative stage; the results were normal. We have not yet made this test in early cases. The laboratory tests have been suggestive only in that the slight leukocytosis usually present might be due to a mild infection.

ROENTGENOGRAPHIC FEATURES

Coxa plana is characterized roentgenographically by the development of areas of increased density within the femoral head, followed by irregular ossification and subsequent repair in the previously dense areas, and accompanied by decrease in the vertical diameter of the affected areas, overdevelopment of the cartilage, and broadening of the head and neck. Some cases may be asymptomatic. A roentgenographic diagnosis of coxa

plana was made in seven such hips in this series; in six of these hips the condition was accidentally discovered during the examination of symptomatic coxa plana of the opposite side.

Prior to the development of any other roentgenographic changes, distention of the capsule of the hip may be demonstrable. Such hips have the clinical features of coxa plana, but they may or may not develop that condition. One patient in this series was under observation for four months before there were any roentgenographic changes in the hip other than a distended capsule. Typical coxa plana then developed in this hip. Such an instance is believed to demonstrate the presence of recognizable subacute arthritis in the hip joint before the appearance of the changes of coxa plana in the femoral head.

The sequence of roentgenographic changes may be divided into the following stages:

Incipient Stage: This is the period before the appearance of dense areas in the femoral head. In this stage the condition may be abortive and may resolve after developing slight changes, such as a wide joint space and flattened crest of the head. Other hips present only very slight changes, such as a distended capsule and slight widening of the epiphyseal line—a potential coxa plana—but resolve without developing any characteristic changes in the head. In children of eight or nine years, such cases are indistinguishable from the preslipping stage of slipping of the upper femoral epiphysis, except that at this age coxa plana is rare in females and slipping epiphysis is rare in males. Cases in the incipient stage have the clinical appearance of the active stage.

Active Stage: This stage is characterized by the appearance of dense areas in the femoral head and it continues until the dense areas begin to resolve into irregular ossification. In some instances, new dense areas may have appeared, in which case activity and repair may be said to be present in different parts of the head at the same time. Rarely, due to some aggravation of the condition by injury or by further inflammation of the joint, new dense areas may appear after the epiphysis is well into the stage of repair. Such an event is a relapse. When the dense areas have disappeared, no further flattening of the head occurs, except in the case of a relapse or of very poor adaptation of the head to the acetabulum. Hips which roentgenographically are entering the active stage present clinical evidence of activity, but the transition to the clinical reparative stage may precede or follow the roentgenographic transition. The divergence may be due to: (1) forms of treatment which affect the clinical evidence of activity without altering the roentgenographic course, (2) the rapidity of improvement in the condition of the soft tissues as compared to bone under favorable conditions, (3) the presence of small areas of activity within the femoral head while most of the lesion is in the stage of repair, or (4) the fact that regeneration of the bone cannot be expected until there has been some improvement in its circulation brought about by a change in the soft tissues about the femoral neck.

Stage of Repair: The first appearance of irregular ossification in a previously dense area marks the beginning of repair. The reaction to the disturbance of circulation in the femoral head* is an inflammatory process in the affected area. Calcium is absorbed in this area, but is deposited about its circumference, thereby producing a dense area. Under cover of this density, the process goes on until inflammation subsides. Calcium is then absorbed from the dense circumference and the irregular, sometimes complete, absorption of calcium within the dense area becomes visible as an area of irregular ossification or lack of ossification (simulating a cavity). The unossified portions then gradually re-ossify irregularly and, when these portions are fairly well ossified, the texture of the bone in this area improves until finally repair is complete. Until the process begins to subside, the surrounding density is too great to allow the bone absorption to be seen; when absorption (irregular ossification) is visible, there may still be a line of increased density at the margins of the affected area where the dense material is viewed tangentially. It is evident from this that increased density marks the active stage and irregular ossification, which appears the more alarming, marks the presence of repair; also, that, as two or more dense areas may not lose their density at the same time, activity and repair may be present concurrently in different parts of the same femoral head.

It may also be noted that irregular ossification may occur in the areas of overdeveloped cartilage about the head, especially near the neck. In this event there is no dense area, as the material is cartilage and no changes are visible within it until ossification begins, usually irregularly. The appearance of bone formation in this cartilaginous area is, of course, a reparative process.

Cases which roentgenographically present no evidence of activity (dense areas) are generally in the reparative stage clinically. The exceptions are usually cases in which the hip has been traumatized by too much activity or by too energetic treatment in the form of manipulations or stretchings.

The time from the onset of symptoms to the beginning of repair varies greatly. Some cases may be a year in the incipient and active stages; others may be in the stage of repair when first seen a few weeks after onset of symptoms. These differences are probably more closely related to the promptness with which symptoms appear than to differences in duration of the active stage in a given area.

Of the fifty-five hips examined within one year of the onset of symptoms, forty-five had irregular ossification of the femoral head, or developed it while under observation. In one-half of these forty-five hips, repair was present in all involved areas within nine months. Only twelve were known to have irregular ossification within less than six months after the onset of symptoms; nine of these were hips in which irregular ossification did not develop in more than one-third of the head in each

*See Part I of this study.

case.* Of eighteen hips examined before irregular ossification appeared, only four were known to be without it for as long as six months after the onset of symptoms.

From these findings, it seems probable that irregular ossification (the evidence of repair) is not to be expected in less than five or six months, but it is likely to be extensive in nine months. When areas are involved successively, the area last involved is usually the first to be completely repaired,—that is, the process is worst in the area first involved. The cases which reach the stage of repair slowly are liable to involve the head extensively, while in the cases which are quicker in reaching the stage of repair the involvement is generally localized in the middle, the outer, or the inner third of the head, in that order of frequency. But cases having a localized involvement when first seen may later develop involvement of other areas; it has not been found possible, therefore, to offer a prognosis based on the extent of the involvement when first seen. As the head eventually regains a rounded contour derived from its highest remaining part, in cases where only one-third of the head is involved it could be predicted that the head would regain a normal contour, except for the fact that, until repair is present throughout, one cannot be certain that further involvement will not occur. This exception is sufficient to reduce greatly the value of prognosis on this basis, as well as to nullify the value of distinguishing the so called cap type from the mushroom type, except when that distinction is made late in the stage of repair.

The stage of repair is very long. The course from the onset of symptoms to the completion of repair may be expected to occupy from four to seven or more years. This course may be favorably affected by complete rest from weight-bearing or by the drilling operation (described later), but, with any other treatment, the course is not materially affected (unless it be for the worse) and deformity is often unnecessarily great.

Residual Stage: When repair is complete, the residual stage is reached. In most cases, cartilage has grown down extensively over the neck in the previous stages. In repair, much of this cartilage ossifies. Especially is there a tendency to formation of a dense line of bone at the distal margin of this cartilage about the neck. This dense line may be seen crossing the neck, often quite near the trochanters. When this line is clearly visible, the residual stage may be said to have been reached. Occasionally there is need of slight further repair, but usually repair is quite complete when the line mentioned is definite across the entire neck.

There is much less tendency to arthritis in adult life in this condition than in slipping epiphysis, but arthritis occurs fairly frequently if there is much deformity residual from the coxa plana.

DIAGNOSIS

A child between the ages of three and twelve years, complaining of a limp or pain in the hip, thigh, or knee, may have coxa plana. The hip

*There were nineteen such hips in the whole series.

should be carefully examined for limitation of motion, particularly internal rotation and abduction or adduction, and for spasm and pain at the limits of motion. The presence of these physical findings, even in slight degree, indicates the need of a roentgenographic examination, by which the diagnosis can almost always be established. In questionable cases, the patients should be carefully observed, their activities should be limited, and repeated roentgenographic examinations should be made.

The roentgenographic and other features of this condition are so different from those of other conditions of the hip occurring in this age period—fracture, dislocation, osteomyelitis, suppurative arthritis, acute rheumatic fever, and bone tumors—that differential diagnosis should present little difficulty after a careful and complete examination has been made. Tuberculosis of the hip may be differentiated by its more acute symptoms and signs in the early stages, by the laboratory findings, and by its roentgenographic features,—that is, thinning of the joint space, local decalcification, lack of broadening of the neck and head, and, later, destruction at the surface of the bone. Non-suppurative arthritis may be distinguished by the absence in the roentgenogram of the features characteristic of coxa plana. It may be impossible to differentiate slipping epiphysis in the intermediate age group (from eight to ten years) until slipping occurs or until the specific changes of coxa plana develop.

COURSE IN UNTREATED CASES

When no treatment is used and the disease is allowed to follow its natural course, that course is usually somewhat as follows: The onset may be sudden or gradual and is accompanied by a limp or pain which is usually slight at first but increases as the disease progresses. Disability is variable and is usually proportional to the severity of the symptoms. At this time there is limitation of motion and pain and spasm on motion. In the roentgenogram the femoral head is flat and irregularly increased in density, and the joint space is wide. After a variable period, usually six to twelve months, the symptoms and signs gradually subside over a period of one to two years, although the limp and slight limitation of motion may persist indefinitely. In the meantime, the roentgenogram of the femoral head reveals the disappearance of the increased density and in its place irregular ossification, which gradually returns to normal texture. The flattening of the head and widening of the joint space often disappear entirely, but the head may have become permanently deformed,—that is, broad and flat with a broad neck, an enlargement rather than a true mushrooming.

RESULTS OF VARIOUS TREATMENTS

If treatment does not shorten the course or diminish the severity of the disease and its sequelae symptomatically, objectively, or anatomically, it has failed. The results of the various treatments were evaluated by a comparison of the symptoms,—pain, fatigue, limping, stiffness, disability;

of the signs, limping, pain on motion, spasm, shortening, and limitation of motion; and of the roentgenograms in various stages.

Braces were used for a variable period (two months to two years) in the treatment of sixteen hips. Several of the braces were of the traction type and weight-bearing was not permitted. The hips treated by this type of brace showed the slowest repair and the greatest residual limitation of motion of any group in the whole series, although at onset they were not the worst group. This outcome can probably be explained by the effect of immobilization on the inflamed and poorly vascularized tissues of the hip.

Plaster spicas were used for one to nine months in the treatment of ten hips; recumbency was maintained in several cases. The results in these cases were intermediate between the untreated cases and those treated with braces.

No case in this series had constant prolonged rest in bed without other treatment. However, several cases seen more recently suggest that in cases so treated motion is improved, repair is more rapid, and deformity is less marked than in cases treated by other non-operative methods. However, some of these hips progress in the extent of involvement and deformity of the femoral head and, in this respect, the results appear inferior to those obtained from treatment by the drilling operation. Partial or intermittent rest in bed seemed to have little effect on the course of the disease. Complete rest for short periods (one to three months) improved motion and reduced spasm, but had no obvious effect on the development or progress of bony changes.

RELATION OF DEFORMITY TO FUNCTION

In the active and reparative stages of the disease, there was no direct relation between the flattening or broadening of the ossified portion of the femoral head and the limitation of motion. The limitation varied directly, however, with the acute signs: pain on motion, tenderness, and spasm. These observations were substantiated in the hips operated upon by the fact that there was no flattening of the cartilage of the head to correspond to that of the ossified portion shown in the roentgenogram. Furthermore, at operation, it was constantly found that the limitation of motion was due to inelasticity of the synovial membrane and capsule rather than to bony or cartilaginous block, although in patients under anaesthesia the motion was greater in the hips in which acute inflammation was present.

In the residual stage, in cases with marked flattening and widening of the head, abduction and rotation were usually limited correspondingly. On the other hand, in residual cases, the hips with smoothly rounded heads sometimes had a distinct limitation of motion, apparently due to soft-tissue scarring. These observations indicate that the impairment of function is usually and largely due to the effects of inflammation of the soft parts. The treatment of this inflammation is of primary importance

and the proper treatment for the inflamed tissues is rest as described in the following paragraphs.

AN OPERATION FOR EARLY CASES

On the theory that the changes in the femoral head and neck in coxa plana were brought about by a disturbance in the circulation of the epiphysis secondary to the soft-tissue inflammatory changes, and because healing in coxa plana is sometimes associated with deformity and is usually quite prolonged, due to the residual scarring and poor circulation, an operation was devised for revascularization of the femoral head. This operation was first used in April 1928.

The hip is exposed through a Smith-Petersen incision, and the capsule is incised anteriorly. The hip is then inspected and specimens of synovial membrane and capsule are taken. A small window is cut in the cortex of the femoral neck proximally (the bone and periosteum are retained for the laboratory). Through the opening, several holes are drilled with curved awls and curets into the femoral head in various directions. The opening is closed with a bit of muscle to prevent bleeding into the joint. Careful hemostasis and anatomical closure are made, and a snug adhesive strapping and a flannel spica are applied.

This operation was used in the treatment of coxa plana in fifteen hips from April 1928 to June 1932. There were no deaths and no serious infections. Active motion was allowed within two days of operation, and ordinarily the pre-operative motion had been regained within two weeks. However, weight-bearing was not allowed for several months, the length of time varying with the duration of pain and spasm and the roentgenographic appearance. This operation, combined with rest in bed, without immobilization, until spasm was absent and motion was improved, gave the following results: The repair in the bone began immediately; no new areas of increased density developed; the reparative stage was greatly shortened; the clinical condition always improved. The hip may become perfectly normal clinically and roentgenographically; this result has not been observed in patients who have not been operated upon, except in abortive cases.

CHOICE OF TREATMENT

From a study of this series of cases, our conclusions as to treatment are:

General treatment should include the elimination of foci of infection and the adequate treatment of active infections that arise.

In the early or active stage, the primary consideration in treatment is rest, particularly from the strains accompanying weight-bearing. The best method of obtaining rest ordinarily is to keep the child in bed without traction or a brace. However, in the presence of acute pain and spasm, simple adhesive or anklet traction may be used for a short time for their relief, and such traction may be used for restraint when necessary. How-

ever, traction should be avoided if possible. The use of casts, and particularly traction braces, is strongly advised against; while they provide rest, they also encourage subsequent limitation of motion. Rest should be maintained as long as definite pain on motion and spasm persist and until roentgenographic examination indicates that repair has progressed sufficiently for the ossified femoral head to support the articular cartilage on weight-bearing. Stretching and forcible manipulation should not be done in either the active or reparative stages.

The drilling operation is as yet experimental and its value has not been fully proved; it is technically difficult and there is danger of serious damage to the hip. It is believed that if the operation is properly performed, when the inflammation in the hip is not too active, it will hasten the repair and prevent further deformity of the femoral head. At present we use this operation in all cases not yet well into the stage of repair, but we do not advise its use except by those who are experienced in hip surgery and who are certain of performing the operation with a minimum of trauma to the soft tissues.

In the reparative stage, no treatment is indicated. Activities which would cause a severe wrench or trauma to the hip—such as jumping from a height, skating, and playing football—should be prohibited. If there is much limitation of motion, rest in bed for two or three months should be tried.

In the residual stage, treatment is directed at the result only of the disease and may consist of judiciously selected subtrochanteric osteotomies, reconstructions or arthroplasties, or exercises.

SEQUELAE

Of the five cases which had reached the residual stage and in which the patients were more than seventeen years of age, only two presented the changes of degenerative arthritis upon roentgenographic examination, as contrasted with the cases of slipped epiphysis in which all of the patients past this age were arthritic. Of the seventy cases in which the patients were under the age of seventeen, degenerative arthritis was found in five cases.

CONCLUSIONS

1. Eighty-five per cent. of the seventy-five patients with coxa plana were males.

2. Bilateral coxa plana is not infrequent and should always be looked for. The condition may not occur in the two hips at the same time or in like degree.

3. Stature, obesity, and endocrine imbalances appear to be unimportant in influencing the incidence of the condition.

4. Trauma appears to be of importance only incidentally in increasing the symptoms and the activity of the process.

5. No definite epidemic or seasonal relationships are found.

6. The onset of symptoms and of roentgenographic changes usually occurs between the ages of three and ten years.

7. The pathological features are acute inflammation of the soft tissues about the neck, and their subsequent sclerosis, thickening, and avascularity.

8. Sclerotic changes about the neck are accompanied by a vascular disturbance in the femoral head, resulting in the bony changes characteristic of coxa plana.

9. There are three stages,—active, reparative, and residual.

10. Definite symptoms, physical signs, and roentgenographic evidence of the disease are always present in the active stage. Early diagnosis is essential for the best results in treatment.

11. Final impairment of function is not proportional to deformity of the head.

12. Adequate rest for the hip is the most important factor in obtaining a good result.

13. In our cases in the active stage, drilling of the femoral head for revascularization has halted the advance of the process and has resulted in earlier and more complete repair.

14. In the reparative stage, when activity has completely subsided, no treatment is usually indicated. In the residual stage, subtrochanteric osteotomy, or arthroplasty, may be desirable in selected cases.

15. Degenerative arthritis is a sequela in some cases.

APPENDIX

The roentgenographic features of coxa plana have not been fully discussed in the literature. For that reason, they are tabulated here approximately in the order of their appearance. The features are assembled in certain numbered groups. Cases will be found in which a feature listed in one group may first appear in an earlier or later group. The more transient features are followed by a numeral which signifies that, by the time the features of the group indicated by the numeral have developed, the transient feature will probably have disappeared.

1. *Incipient Stage*
   Distended capsule.
   Cartilaginous joint space wide, especially inferiorly.
   Slight flattening of the crest of the head.
   Slight radiolucence of the neck at the epiphyseal disc.
   Widening of the epiphyseal disc.

2. *Active Stage—Early*
   Dense line at the crest or base of the head.
   Shallowness and broadening of the head.

3. *Active Stage—Late*
   Irregularity of the neck (6).
   Dense areas within the head.

Greater degree of widening of joint space, shallowness of head, and broadening of head and neck.

Occasionally some decalcification of the innominate bone and upper half of the femur (5).

Ischium varum, common (6). Ischium varum is a transient feature not present until late in the active stage and, therefore, cannot be considered to be a cause of coxa plana.

Atrophy of thigh demonstrable roentgenographically (6).

Protrusion of the head laterally beyond the ilium, due to broadening of the head and widening of the cartilaginous joint space inferiorly.

Body of the pubis on the affected side smaller than normal. This is not necessarily permanent.

4. Transition from the Active to the Reparative Stage

Decrease of density in previously dense areas, with appearance of irregular ossification as the density decreases.

New areas of density may have appeared while the first areas were becoming irregularly ossified.

Occasionally irregular ossification in cartilaginous areas at the margins of the epiphyseal line.

Obliquity of the roof of the acetabulum (6).

Lengthening of the acetabulum (6).

Occasionally semblance of separation of a fragment of bone at the surface of the head, due to the extensive loss of texture in developing irregular ossification (6). This may be designated as osteochondritis-dissecans type of coxa plana (See Part I of this study).

5. Reparative Stage

Dense areas are almost completely replaced by irregular ossification which is becoming less irregular.

Line of increased density may persist at margin of area of irregular ossification.

Coarse texture of the trabeculation of the femoral neck (6).

Narrowing of the shaft of the femur (6), not common.

Occasionally semblance of cavity in the head or in the neck adjacent to the head, due to extensive loss of texture of the head in developing irregular ossification.

Advanced ossification of epiphyseal discs of the trochanters or cartilage plate between the ilium and ischium.

6. Reparative Stage—Late

Texture of the affected areas tends toward normal.

Head becomes less flat, the rounded contour being derived from the highest remaining point of the head.

The broadened head may have spread down over the neck in the regions where the edge of the head had been irregularly ossified.

Acetabulum tends to conform to the contour of the head.

Shortening of the neck, due to deficient growth in length, is common.

Distention of capsule diminishes, if it has not already done so.

Joint space becomes less wide.

7. Residual Stage

Margin of the head where it has grown down over the neck develops a dense line crossing the neck, often quite near the trochanters. When this line is definite the process may be regarded as completed, although occasionally there is a little further repair to be accomplished.

Head has become rounded unless pressure of the upper lip of the acetabulum on a subluxated or broad femur interferes with rounding.

Rarely, and only after mild affections, there is lengthening of the neck.

Thinning of joint space. This is uncommon. Although such an occurrence is rare, it may also take place early in the process when the infectious arthritis preceding coxa plana has been unusually severe (See Part I of this study).

DISCOID EXTERNAL SEMILUNAR CARTILAGE *

A Cause of Internal Derangement of the Knee Joint

BY JEROME G. FINDER, M.D., IOWA CITY, IOWA

Recent reports [1] disclose that lesions of the external semilunar cartilage of the knee joint are more frequent than the earlier statistics indicate. A seldom recognized, rare, congenital anomaly of the external cartilage occurs as a complete disc. Occasionally, this aberration may produce symptoms which lead the clinician to a diagnosis of "internal derangement of the knee joint". This designation is unsatisfactory from the standpoint of pure diagnosis, since it is indefinite as to the specific cause of the derangement. While an absolute differentiation may be imprudent in certain instances, the anatomical diagnosis should, nevertheless, be the goal. This objective justifies the presentation of certain pertinent findings which, it is believed, may validate the clinical recognition of the existence of discoid cartilages in some cases.

The author was able to find this anomaly described nineteen times in the literature. Three additional cases have recently been brought to his attention: Dunn [1] mentioned a case in a recent paper; Fisher [2] wrote of another, which he diagnosed correctly prior to operation (no other instance is known to the author where such recognition has been made); and a third case is said to be on exhibition in the Museum of the Anatomical Institute of the University of Vienna [3]. The majority of these cases were seen in the anatomy laboratory. However, since 1927, nine cases have been recognized at operation. To this group the author wishes to add three cases, which are the first in the American literature to be reported from a clinical point of view. The entire twenty-five cases are recorded in Table I.

ANATOMY

The complete external fibrocartilage of the knee joint represents a persistence of the embryonic structure. Keibel and Mall [4] state that the knee joint of the embryo of seventeen millimeters is still a dense mass of tissue. In the embryo of twenty millimeters, the tissue becomes greatly condensed into a definite perichondrium, while the peripheral mesodermal tissue at the joint becomes transformed into a capsular ligament. Within the potential joint most of the tissue shows signs of becoming less dense, but the menisci and crucial ligaments (like the capsular ligaments) are differentiated directly from the mesoderm. In the differentiation of the articular mesoderm, the menisci are the first structures to become distinct, then the capsule, crucial ligaments, patella, and ligamentum mucosum, in the order named.

* From the Department of Orthopaedic Surgery, State University of Iowa, Service of Dr. Arthur Steindler.

TABLE I

REVIEW OF TWENTY-FIVE RECORDED CASES OF DISCOID SEMILUNAR CARTILAGE

Author	Country	Year	No. of Cases	Sex		Age at Onset* (*Years*)	Where Recognized
				Male	Female		
Young [9]	England	1889	3				Anatomy laboratory
Higgins [10]	United States	1895	2				Anatomy laboratory
Poirier et Charpy [11]	France	1911	2				Anatomy laboratory
Fick [12]	Germany	1911	1				Anatomy laboratory
Fisher [13]	England	1924	1				Anatomy laboratory
Bristow [14]	England	1927	1		1	13	Operation
Langer [15]	Austria	1928	2				Anatomy laboratory
Fairbank [16]	England	1930	2				Operation
Ellis [7]	England	1932	2		2	13** 26	Operation
Duncan [8]	United States	1932	1	1		27**	Anatomy laboratory
Lloyd [6]	England	1933	2	1	1	12 6**	Operation
Dunn [1]	England	1934	1		1	17	Operation
Fisher [2]	England	1934	1	1		20	Prior to operation
Finder	United States	1934	3		3	9½ 14 15	Operation
Vienna Museum [5]	Austria	?	1				Anatomy laboratory

* Age at onset of symptoms is given where known. ** Bilateral.

In embryos of about thirty millimeters the knee joint first appears between the patella and the femur. Somewhat later, two other cavities appear between the condyles of the femur and the menisci, communicating secondarily with the retropatellar cavity and the cavities forming between the menisci and the tibia. Probably this is the stage in which aberrations are most likely to occur. MacEwen [5] suggests that the size and shape of the cartilage are determined by a balance between the growth of the cartilaginous center and the liquefactive processes by which the joint cavities are formed. If the center of chondrification extends beyond the normal limits in the differentiating mesoderm of the meniscus (before the joint appears), a large discoid or ring-like cartilage may form and may persist throughout the later stages of development. The extension of the cartilage growth center may be a manifestation of excessive

FIG. 1

Complete discoid external semilunar cartilage of the left knee (Case 3), viewed from the superior (femoral) surface. The anterior margin is below, the posterior margin above.

activity. On the other hand, there may be a failure or retardation of the liquefactive processes to inhibit the overgrowth of cartilage. Just why the external meniscus should be affected is unknown.

Ordinarily, the complete disc is not present in any animal higher than the lizard or crocodile family, although a complete ring is found normally in certain apes, and, occasionally, in man.

The presence of an anomalous cartilage, *per se*, produces no specific pathological changes. Grossly, the cartilages may appear as biconcave discs of circular, oval, or rounded quadrilateral shape (Fig. 1). The cartilage is of normal or moderately increased thickness peripherally, but thins centrally to from one to three millimeters. Some cartilages disclose deficiencies, varying in size from a pea to a bean, at the mid-portion of the medial marginal attachment.

Of the three cases here reported, two showed excessively large fat pads which were adherent to the external cartilages and encroached upon

FIG. 2

Low-power photomicrograph, showing typical fibrocartilaginous structure (Case 3). Section taken through the transverse diameter of the disc.

the articular space, probably contributing to the "locking" syndrome. Such fat pads sometimes cause mechanical interference with the joint action which may lead to secondary traumatic arthritis. Microscopic examination of the central portion of the disc revealed normal, mature fibrous cartilage (Fig. 2).

SYMPTOMS

It should be emphasized that complete discoid external fibrocartilages may never give rise to symptoms. However, those which do present signs

often begin to do so in childhood. The available data indicate a higher incidence in females, who outnumber the males in the ratio of eight to three.

In uncomplicated cases, a finding strongly suggestive of discoid cartilage may be elicited as the knee is passing through the last fifteen or twenty degrees into full extension. During this manoeuver, one can observe the external tuberosity of the tibia "suddenly bumping and jolting forward on the femur like the wheel of a train running over an obstacle" (Lloyd [6]). Simultaneously, a "popping" sound is usually heard. This "pop" has been described also as a "thud" (Ellis [7]) and a "bump" (Lloyd [6]). The sound is rather distinctive and differs from the clicking or crepitating noises frequently heard in joints. In this uncomplicated group, all other subjective symptoms may be absent. Cysts of the external semilunar cartilage may produce a similar sound. In a number of cases of discoid cartilages both sides have been affected; when such a condition is demonstrable, it is diagnostically significant.

When injury occurs, the clinical picture is somewhat altered. Unless the "jolting-popping" syndrome presents after the trauma, or is known to have existed previously, it is difficult to distinguish between this anomalous condition and the more common internal derangements of the knee joint. In the differential diagnosis, one should also consider cyst of the external semilunar cartilage and "trigger knee".

Roentgenograms must be interpreted with caution in the light of the clinical findings. A widening of the lateral joint space (found in all three cases here described) may be evidence of an enlarged external discoid cartilage. On the other hand, the widening may be relative only to an actual diminution of the medial joint space, following an internal meniscus lesion.

TREATMENT

The treatment of all cases giving rise to symptoms is surgical, and consists of the removal of the discoid external fibrocartilage through a lateral incision. However, when the diagnosis is uncertain, the medial parapatellar incision (utility incision) may be employed to advantage. By this approach, an adequate exposure is realized and the possibility of overlooking any abnormality within the knee joint is minimized. Following operation, the encouragement of early motion is most important.

CASE REPORTS

The following histories are those of three girls, whose symptoms began at the ages of nine and a half, fourteen, and fifteen years, respectively. Symptoms preceded surgery by four months to three years. Trauma was a factor in one case only.

CASE 1 *. M. P., white female, aged eleven years.

History: For eighteen months, the patient had noticed a visible jarring motion, accompanied by a "popping" sound in the right knee, when walking upstairs. She amused her playmates by "popping her knee".

* From the Service of Dr. Philip Lewin, Chief of the Department of Orthopaedic Surgery, Cook County Hospital, Chicago, Illinois.

Examination: Symptoms were elicited on extending her knee from 165 degrees to 180 degrees. Roentgenograms showed some increase of the lateral joint space.

Diagnosis: Cyst of the external semilunar cartilage.

Operation: The external cartilage was removed through a lateral Jones incision. The cartilage was in the form of a quadrilateral, biconcave disc whose rounded edges were attached except at the anterolateral margin.

Course: The patient made an uneventful recovery, with a full range of motion and absence of "popping".

CASE 2. C. S., white female, aged fourteen years.

History: This patient entered the hospital originally because of an adolescent scoliosis. She was sent home to perform corrective exercises, in the course of which the symptoms of "locking" developed in the left knee. However, she could force the knee into full extension, to the accompaniment of a loud "pop", after which the motion would be unrestricted except for transitory swelling and pain. Several such accidents occurred while she was resting in bed.

Examination: This patient was tall, asthenic, and hypotonic. Malposture, moderate dorsolumbar scoliosis, and a general laxity of most joints were noted. When not "locked" the knee appeared to be normal, except for tenderness laterally. Roentgenograms of both knees were similar to those in Case 1.

Diagnosis: Ruptured external semilunar cartilage; lesion of internal cartilage (?).

Operation: The complete discoid external cartilage was removed through a utility incision. An extremely large fat pad was found attached to the external cartilage, extending well into the joint.

Course: The patient was very timid about active motion and weight-bearing. Two manipulations were required before she was ultimately discharged with a painless range of motion between 80 degrees and 180 degrees. (Under anaesthesia, complete, relatively free flexion was possible.) During the period of rest in bed, the right knee "locked" on three distinct occasions. This case, which may be a bilateral anomaly, is still under observation.

CASE 3. A. F., white female, aged eighteen years.

History: This girl, while dancing, slipped and wrenched her left knee. "Locking" recurred several times thereafter. "Something in the knee seemed to slip out" and could be replaced by manipulation. Examination at that time revealed a snapping and tenderness on the lateral side of the knee. The patient left the hospital after conservative treatment, but returned three years later with the history that the knee had "slipped" at least thirty times in the interim. A sister had had one experience with locking of the knee joint following a fall, but no recurrence had taken place.

Examination: The muscles of the left lower extremity were weak from a month's immobilization in a plaster splint, but the range of passive motion was complete. Tenderness was present over the medial tibial tuberosity, but was more marked over the lateral. The anteroposterior roentgenogram showed a widening of the lateral joint space.

Diagnosis: Ruptured external semilunar cartilage; lesion of internal meniscus (?).

Operation: The technique was the same as that followed in Case 2. A large fat pad encroached on the joint and was adherent to the external cartilage (Fig. 1), and was also adherent to the capsule.

Course: The timidity of the patient was partly responsible for slowness in obtaining active motion. After one manipulation, motion was free and painless from 90 degrees to 180 degrees. The patient is still under observation.

COMMENT

Discoid cartilages probably exist more frequently than a review of the literature would lead us to believe. Undoubtedly, a number are overlooked, some are unrecognized, while others may be grouped as "hyper-

trophied", cystic, or traumatic cartilages. Exact differentiation is difficult; the preoperative diagnosis was incorrect in the three cases presented. When lesions of the external meniscus are referred to the medial side of the knee, the problem of differentiation grows still more complicated. However, the infrequency of cartilage injuries (especially of the external meniscus) in childhood, the "jolting-popping" syndrome, the bilateral occurrence, and, possibly, the roentgenographic evidence of increased lateral joint space point to the diagnosis of discoid cartilage.

Whenever symptoms present, the removal of the cartilage is indicated, even in those cases where pain and limitation of motion are absent. The mechanical derangement predisposes to traumatic arthritis, or osteoarthritis in later years. It may be the precursor of one of the more familiar injuries of adult knees (Lloyd [6]). However, Duncan [8] found no clinical, pathological changes in either knee joint in a case of bilateral complete discoid cartilage occurring in a Negro who died of pulmonary tuberculosis at twenty-seven years of age.

Exact anatomical diagnosis also proves its value surgically. If the lesion can be definitely localized, the patient may be spared the necessity of a more radical joint exposure and exploration.

SUMMARY

1. Complete discoid external fibrocartilage of the knee joint is a rare congenital anomaly.

2. The condition is of clinical importance because it may produce symptoms which must be differentiated from other internal derangements of the knee joint.

3. Three cases are presented, with a consideration of the anatomical development, the diagnosis, and the surgical treatment of the anomaly.

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INTRAPELVIC PROTRUSION OF THE ACETABULUM

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In the Dutch literature, this deformity has been described but once,—namely, in 1921 by Waller[1]. The patient was a girl aged twenty. At the age of sixteen, she had had trouble with her left hip for a short time. Some weeks before examination she fell on her left side, after which she kept complaining of her hip. The roentgenogram shows a typical bilateral protrusion of the acetabulum, complicated on the left by a fracture of the acetabular floor. An examination two years later showed that the right hip had remained unchanged, but the head of the left femur had penetrated still further inward, so that the greater trochanter was leaning against the pelvis.

The following two cases of this affection have been treated by the author.

CASE 1. A male, thirty-four years of age, a tailor, was first seen in April 1932, complaining of pain in the hips of two years' duration. At the time of the examination he could no longer spread his legs well and had a waddling gait. The legs were rotated outward about 45 degrees. There was flexion in the hips: right, 180 to 80 degrees; left, 180 to 100 degrees. Rotation was impossible; total abduction of both legs was 30 degrees.

The roentgenogram (Fig. 1) shows both cotyloid cavities protruding into the pelvis; the trochanter is standing against the pelvis. On the right, the joint fissure is clearly perceptible; on the left, the femoral head is angular.

Examination in June 1933 showed increasing stiffness of the hips. There was flexion of the hips from 180 to 120 degrees and total abduction was 20 degrees. Culture of the

FIG. 1

urethral mucus showed gonococci. Clinical treatment with autovaccine was instituted.

After three months the pains had completely disappeared; there was flexion from 180 to 90 degrees; total abduction was 40 degrees.

A month later the patient complained of increasing stiffness. Mobility had remained unchanged, but the movements were carried out more slowly. The patient was admitted to the hospital and given sweating baths.

Examination in December 1933 showed: flexion—right hip, 180 to 90 degrees; left hip, 180 to 80 degrees; abduction—right hip, 30 degrees; left hip, 20 degrees. The legs were rotated outward about 20 degrees. The gait showed hardly any defect; the patient could walk upstairs in a normal manner.

Case 2. A woman, forty-five years of age, married, was first treated in June 1933. For five or six years previously she had had pains on the left side in the abdomen and groin. These pains were present especially at night. She walked with a limp in the left leg; all movements of the hip were limited.

The roentgenogram (Fig. 2) shows on the right a deep socket with a thin floor; on the left, protrusion of the acetabulum. The rim of the socket is partly ossified and the femoral head shows several lighter spots. Comparison of this roentgenogram with that taken in 1928 indicated that the cotyloid cavities had not changed; whereas the arthritic alterations had increased.

The patient was admitted to the hospital. Traction was applied and sweating baths were given without any effect. Culture of the cervical mucus revealed gonococci. Clinical treatment with polyvalent gonococcus vaccine was begun.

By the middle of October the gait was normal and the pain had gone. Examination showed: flexion of the left hip, 180 to 70 degrees; abduction, 20 degrees; adduction, 5 degrees; outward rotation, 10 degrees; no inward rotation.

In both patients there existed a chronic gonococcal arthritis coincident with the protrusion of the acetabulum.

In his excellent survey of this affection, Pomeranz [2] drew the following conclusion:

"On the whole, it seems advisable to recognize two different classes of intrapelvic protrusion: (1) an acute type probably infectious in origin; (2) a chronic type occurring in the course of any disease, resulting in an osteomalacia of the hip joint."

In the author's opinion, there cannot be any doubt about the first type,—that is, the acute form. The second case described by Pomeranz is a typical example of this. Concerning the second group, the author believes that the connection of this deformity with any disease should be denied, and that the cause should be looked for in a totally different direction.

When the cases described in the literature are studied carefully, the following points are apparent:

1. Upon anatomical and roentgenographic examination, distinct evidence of inflammation is lacking. In nearly all of the cases, on the other hand, the floor of the socket is exceedingly thin; while in a large number of cases the articular planes are normal.

2. Some of the patients denied emphatically that they had ever before had any trouble with their hips; others declared that they had had some trouble formerly. The normal acetabulum is about two and one-half centimeters deep; in case of protrusion, sockets are found which have a depth of five, six, and even seven centimeters. It is inconceivable that

FIG. 2

in consequence of some disease such extensive alterations in the hip joint could occur without the patient's being at all inconvenienced.

3. The fact that the number of cases of bilateral protrusion is equally as great as the number of cases of unilateral protrusion is in absolute opposition to what may be observed in other arthritic processes of the hip.

4. Among the fifty clear cases of protrusion of the acetabulum which as yet have been reported, we find forty females and eight males; in two cases the sex is unknown. In thirty-five cases, recorded as protrusion of the acetabulum, but where undoubtedly we have to deal with another deformity, the distribution according to sex is eighteen males and seventeen females.

5. When comparing the roentgenograms, with the exception of some slight differences, we always see the same picture. Consequently, we would be forced to the remarkable conclusion that the most diverse diseases always result in one and the same deformation of the hip joint.

6. When the angle between the neck of the femur and the shaft is determined, it is found that in twelve joints this angle is 115 degrees or less, the minimum value being 110 degrees. In twenty-two hips, values between 115 degrees and 120 degrees are found. In two cases only the angle is larger than 120 degrees, but smaller than 125 degrees. One hundred and twenty-five degrees is generally accepted as the normal angle. It should be taken into account that this angle is not constant and that the varying direction of the roentgenograms gives rise to different values. It is striking that in hardly any case is found an angle larger than 120 degrees. In three patients, in whom protrusion resulted from

FIG. 3
I and *II:* Luxation.
III: Subluxation.
IV: Normal hip joint.

an acute arthritis, angles are found of 127 degrees, 130 degrees, and 150 degrees. In addition to the typical deformity of the acetabulum, we evidently also have to deal here with a curvature of the neck of the femur in the direction of a coxa vara; whereas we might rather expect a coxa valga.

On the strength of these points it is the author's opinion that every connection with any disease should be denied. In setting up a new theory we have to start from the following three points:

1. The occurrence mainly in women.
2. The large number of cases of bilateral protrusion.
3. The fact that all of these cases show practically the same picture.

These three points are found in connection with another affection of the hip joint, which has been known to us for years,—namely, congenital luxation and subluxation. The author believes that protrusion of the acetabulum is the result of a congenital deformity of the hip joint, which may be placed on a level with congenital luxation. The primary cause is a too deep acetabulum, resulting in a too thin acetabular floor.

Figures 3 and 4 are tracings of roentgenograms which indeed show a gradual transition. Starting with a case in which there is an exceedingly

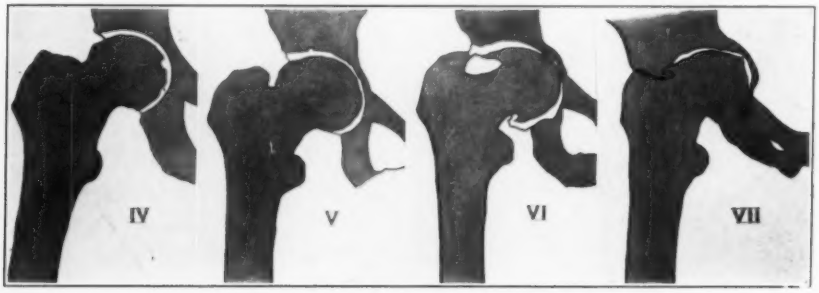

FIG. 4
IV: Normal hip joint.
V: Too deep hip joint.
VI and *VII:* Intrapelvic protrusion.

flat acetabulum, we find the transition to the normal socket, followed regularly by the too deep socket, and finally by the protrusion of the acetabulum.

The author feels that this conception offers a satisfactory explanation of all other deformities found in patients at an advanced age. The hip joint is situated in the very place where the three pelvic bones join, so that the floor of the socket consists mainly of cartilage during a considerable part of the development. When the floor of the socket is of normal thickness the resistance is sufficient to withstand the pressure exerted on it. It stands to reason that a too thin acetabular floor cannot offer sufficient resistance. The result is that slowly but surely the floor of the socket is pressed into the pelvis, so that in the more serious cases protrusion of the acetabulum finally occurs. At the same time it should be taken into account that defects may occur in the normal process of development and ossification, due to the changed conditions of pressure. At about the twentieth year complete ossification has taken place, so that, on the whole, after that age the deformity will not increase. According to this conception, it is credible that the patients are ignorant of the existence of the deformity, for it develops so slowly that they can gradually adapt themselves to the altered conditions. The patients do not begin to complain until arthritic changes develop. We need not be astonished that a joint, which because of its abnormal structure must be regarded as inferior, occasionally becomes the seat of an arthritic process.

It is the author's opinion, therefore, that in cases of protrusion of the acetabulum two forms should be sharply distinguished:

1. That originating in consequence of an acute arthritis of the hip joint.
2. That resulting from a congenital too deep acetabulum.

In reality this conception agrees completely with Eppinger's statement, but, because he thought that the deformity arose at a more advanced age, his explanation became so involved that it was impossible to regard it as correct.

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THE RÔLE OF BONE MARROW AND ENDOSTEUM IN BONE REGENERATION

An Experimental Study of Bone Marrow and Endosteal Transplants*

BY W. H. MCGAW, M.D., AND MAXWELL HARBIN, M.D., CLEVELAND, OHIO

Curiosity and the confusion attendant on reading some of the extensive medical literature on bone regeneration led to the undertaking of these simple experiments with endosteum and bone marrow. These tissues have perhaps received less than their due share of attention, although there has accumulated a mass of detailed study on many phases of osteogenesis.

The search for physiological surgical aids in the treatment of fractures and their complications has led to the use of many types of grafts which have been enthusiastically advocated by as many supporters and which have been used with almost uniform success. The problem of adequate internal splinting by grafts, although still of great importance, has given ground to the problem of the osteogenic properties of grafts,—a shift from the mechanical to the physiological view-point.

One is impressed by the universal supremacy accorded to grafts which include periosteum; one is also impressed by studies that indicate that the other elements of bone may also share prominently in the whole process of regeneration. The osteogenic properties of the cambium layer of the periosteum, first reported by Duhamel in the middle of the eighteenth century, have been well established by the work of Ollier[1] (1867), Axhausen[2] (1908, 1911), McWilliams[3] (1916), and Phemister[4] (1914); and the inclusion of periosteum in bone grafts has been advocated by Delangénière[5], Mock[6], Haas[7], Albee[8], and many others.

Independent growth of cortical or compact bone deprived of periosteum and endosteum is possible, as shown by the work of Ollier[1], Macewen[9], and Phemister[4], but this growth is slow and scanty. With adequate blood supply, transplanted cortex will survive and in time, according to Wolff's law, will follow the plastic changes found in normal bone. How extensively the process of creeping substitution goes on in live cortical grafts is not yet established.

Many investigators have ascribed osteogenic properties to endosteum and bone marrow, although their importance has usually been given a secondary place. Even Ollier[1] showed that a tube inserted into the medullary canal soon became filled with bone. This view was confirmed by Barth[10], Axhausen[2], Macewen[9], and Groves[11]. The cultivation of bone cells *in vitro* sheds light from another angle on osteogenesis and the

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possible survival of grafts. Dobrowolskaja[12], in his experiments, reports slight growth of bone cells from periosteum alone, a steady growth of bone cells from pieces of cortex, and luxuriant cell proliferation from spongy bone containing marrow. More recently Johnson[13], after proving that the intact circulation of nutrient arteries, which supply the bone marrow and inner half of the cortex, allows most rapid bone repair, in his ingenious study of the blood supply of the diaphysis, states: "The medullary callus was the earliest and most active factor in the repair of cortical defects." He also shows that the periosteal blood supply, which nourishes the outer half of the cortex only, stimulates bone growth to a lesser degree and is unable to afford collateral circulation to the medulla in less than four weeks. Berg and Thalhimer[14] report: "The few transplants which included endosteum, though not enough to allow any definite conclusions to be formed, showed an even greater growth from endosteum than any other transplants, even including periosteum."

The only recent study of the osteogenic properties of bone marrow and endosteum was reported by Rohde[15] in his experimental attempts to resect periosteum and cortical bone leaving intact (?) the bone marrow. However, in spite of the great technical difficulties offered by such a procedure, he ascribes the subsequent repair of the ulnar defect to regenerated periosteum, although the periosteum had been scraped off from the stump ends.*

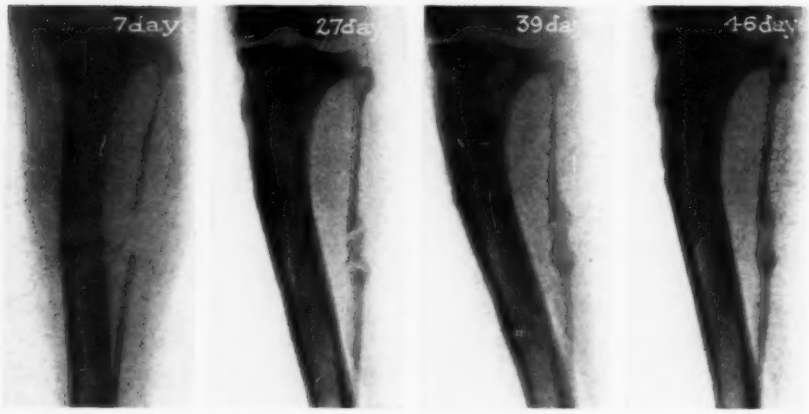
Histologically, the richest supply of osteoblasts is found in the bone marrow. No one, however, has suggested that marrow tissue alone can be used as a free graft to stimulate or to hasten osteogenesis. The following experiments on adult dogs seem to indicate that bone marrow and endosteum, which are easily obtained, may be of clinical use for this purpose.

METHOD

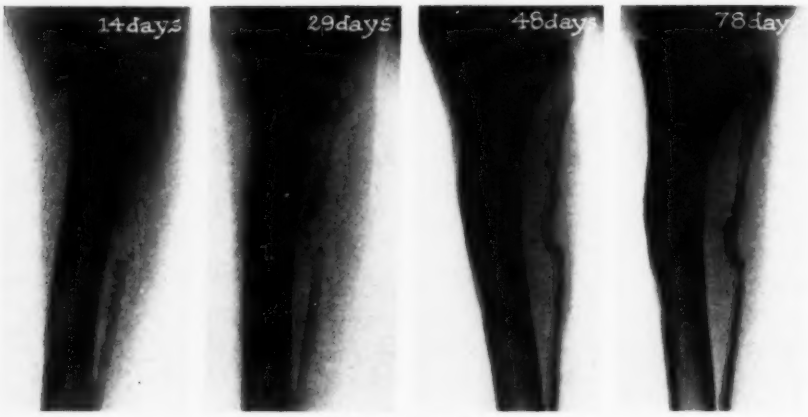
Free autogenous bone marrow and endosteal grafts were placed into the resected portions of one fibula in each adult dog. The other fibula was resected in a similar manner to serve as a control. A quarter of a grain of morphine sulphate was given to each dog before ether anaesthesia. Both hind legs were prepared and, through lateral incisions, three-eighths of an inch of each fibula was resected with its periosteum. The incision in the control leg was immediately closed with silk. Next, an incision over the upper part of the tibia was made and, through a rectangular window in the cortex, bone marrow and endosteum were removed with a small curet. A few small spicules of inner cortex usually came away in scraping off the endosteum. This thin fatty marrow and the endosteum removed from the tibia were then laid into the bony defect of the fibula that had been prepared for the transplant. The muscles were loosely approximated with a single mattress suture, and the incision was closed with silk. Next the piece of tibial cortex was replaced and the incision was likewise closed.

* See Rohde's article, page 757, Figure 16.

Experiment 32



Experiment 31



Experiment 13

FIG. 1

Autogenous bone marrow transplants into extraperiosteal resections of fibulae.

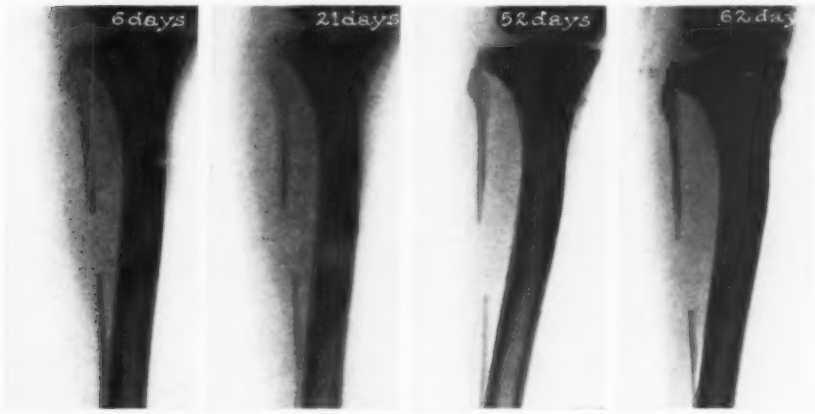


FIG. 2-A
Experiment 19. Control. Right fibula resected with periosteum.

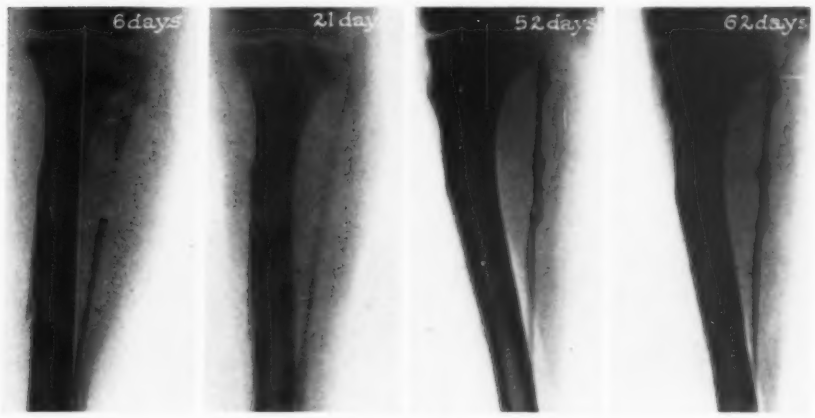


FIG. 2-B
Experiment 19. Bone marrow transplant. Left fibula resected with periosteum.

Six adult dogs were used for this experiment and the progress of bone regeneration was studied by roentgenograms taken at varying intervals (Figs. 1 and 2-B). Series of roentgenograms of four dogs are here shown, but the control roentgenograms of only one dog (Fig. 2-A) are included since the results obtained from the controls were monotonously uniform; all showed marked atrophy of the stumps with no evidence of bone regeneration. Uniform results were obtained in all six animals. The periosteum was removed in each case, thus eliminating its favorable influence on bone regeneration.

SUMMARY OF INTERPRETATION

In all cases a hazy shadow of the bone marrow and endosteal scrapings is just visible on the left side in six to fourteen days. A few spicules of inner cortex are occasionally recognizable.

In twenty-one to twenty-nine days, a distinct diffuse homogeneous callus, with deposition of lime salts in the bone marrow, is clearly seen. This suggests centrifugal growth rather than growth from the periphery. An area of decreased density is evident at each junction of new callus and cortex in many of the experiments, as in Dogs 19, 31, and 32.

In thirty-five to fifty days, the new bone is smoother, thicker, and approximates the density of the original cortical bone.

In about sixty days, there are roentgenographic indications of the formation of a new medullary canal and of cortical condensation, and the new bone is well fused to the shaft of the fibula in each case.

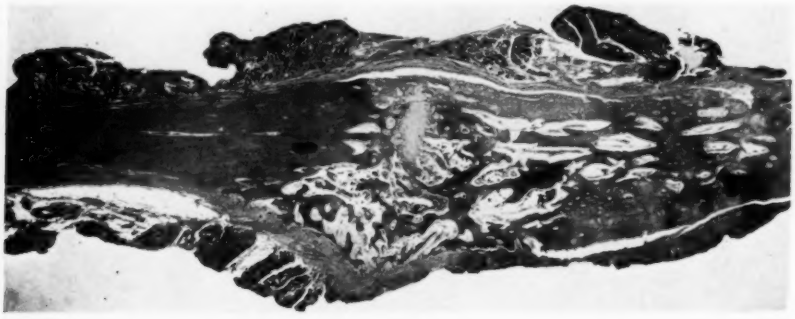


FIG. 3

Experiment 19. Photomicrograph of shaft of left fibula 63 days following operation, showing segment of bone regeneration at right and original cortex at left. × 10

Microscopic studies were carried out and the completed series will be presented at a later date. The photomicrograph (Fig. 3) was made following a biopsy on Dog 19, on the sixty-second postoperative day, after the last roentgenogram had been taken (Fig. 2-B). The block of tissue includes the bone-marrow transplant on the right, the surrounding soft tissue and the adjacent end of the original fibula on the left. The tissue was decalcified in Müller's fluid and stained with hematoxylin and eosin. The defect occupied by the transplant is filled in by newly formed bone which has apparently developed *in situ* rather than by proliferation from the ends of the fibula. This newly formed bone consists of an orderly arrangement of trabeculae containing marrow spaces with beginning cortical condensation under what appears to be regenerated periosteum. Within some of the trabecular interstices the fibrous marrow has given way to hematopoietic tissue.

We believe this[16] to be the first specific experimental evidence relating to the regenerative activity of bone marrow and endosteum, and we expect that its clinical use may prove to be of value.

CONCLUSIONS

1. Bone marrow and endosteum play a very active rôle in the formation of callus and new bone in dogs.

2. Free bone marrow and endosteal transplants will regenerate and bridge extraperiosteal fibular bone defects.

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TREATMENT OF FRACTURES OF THE CARPAL SCAPHOID

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Because of their unfavorable prognosis and relative frequency, fractures of the scaphoid present an important economic problem. Their treatment has been the subject of long controversy in the medical literature, with little agreement regarding the position or duration of immobilization. Many of the methods suggested have added further to the confusion, because they have not been founded upon sound principles.

It is important to differentiate the clinical varieties of isolated scaphoid fractures because the prognosis, as well as the treatment, varies with each type. The most common fracture is one occurring through the middle of the body or neck, which is entirely an intra-articular injury. The second variety is an avulsion fracture of the tuberosity, which is extra-articular, and which heals satisfactorily in five or six weeks with bony union. The third type, which is less frequent, presents a severely comminuted fracture with considerable deformity.

Early diagnosis is absolutely imperative in intra-articular fractures, as failure to institute treatment immediately after injury proves to be one of the main factors in producing non-union. Sixty per cent. of our cases came with a diagnosis of a sprained wrist. In these cases the favorable opportunity for early immobilization had already elapsed. The incidence of pseudarthrosis increases rapidly after two weeks have passed without proper treatment. In any case with a history of trauma of the wrist, tenderness in the anatomical snuff box, and pain in this area on percussion of the tip of the fully extended thumb, a fracture should be suspected, and roentgenograms ordered. Routine x-rays, however, may fail to demonstrate the injury; for it is necessary that roentgenograms of a wrist in which fracture is suspected be taken with the hand in complete ulnar flexion.

TREATMENT

1. *Recent Fractures*

There has been much dispute as to the position of immobilization of the wrist, and the length of time for which such immobilization should be maintained. Almost every position has its advocates,—for example: volar and radial flexion (Speed [1]), slight dorsiflexion and ulnar flexion (Böhler [2]), volar and ulnar flexion (Destot [3]), and extension to about forty-five degrees with slight radial flexion (Berlin [4]). At the meeting of the California Medical Association in 1928, one of the authors (R. S-H.)

presented a method of immobilization of scaphoid fractures which had resulted in bony union in seventy-five per cent. of the sixteen cases treated soon after injury. This method consists of the application of a circular plaster splint which includes the forearm, hand, and wrist, and which holds the wrist in thirty to forty degrees of extension with the hand in *complete* radial flexion. The thumb is included in the splint and placed in abduction and extension.

The accompanying roentgenograms of a typical case demonstrate very well some of the advantages of this position. In Figure 1, taken with the hand in ulnar flexion, there is a definite separation of the fragments of the fractured scaphoid. This is produced by tension of the interosseous ligament which becomes taut when the hand is placed in ulnar flexion, because the ligament extends from the proximal fragment of the scaphoid to the semilunar.

FIG. 1

Roentgenograms of scaphoid fracture with wrist in marked ulnar flexion, showing maximal separation of fragments.

It is to be noted that, in extreme ulnar flexion, the scaphoid leaves the concavity of the articular surface of the radius and moves distally, so that in this position the radial collateral ligament, which inserts on the distal fragment, pulls that piece radialward. Roentgenograms of the hand in radial flexion, however, show the scaphoid fragments closely approximated (Fig. 2), while in the film with radial flexion of the wrist, plus abduction and extension of the thumb, the fracture line is difficult to find (Fig. 3). This clearly answers the question of position in the lateral plane. In regard to the anteroposterior plane, the importance of placing the wrist in dorsiflexion has been proven anatomically by the experimental work of Berlin [4], which showed that, upon volar flexion of the wrist, the fractured surfaces separate on the dorsal side because of ligamentous pull.

FIG. 2

Roentgenogram of the same fracture with wrist in radial flexion. Separation of fragments is less marked, though fracture line is still visible.

FIG. 3

Roentgenogram of the same fracture with wrist in radial flexion and thumb forcibly abducted and extended. The trapezium has so pressed the scaphoid fragments together that the line of fracture cannot be distinguished.

Proper immobilization of the thumb is indispensable to the success of treatment, as by its inclusion a more thorough fixation is possible, and especially because any movement of the thumb involves the long flexor tendon and the abductor pollicis which are closely associated with the scaphoid. The abductor pollicis brevis originates in the anterior annular ligament and in the tuberosity of the scaphoid; therefore, movements of abduction of this digit will produce motion in the distal fragment. The tendon of the long flexor of the thumb swings around and under the scaphoid so that, in full extension and abduction of the thumb, the tendon is taut and serves as a supporting hammock; this support is further completed by the anterior carpal ligament which is attached to the scaphoid on the radial side. The immobilization should be carried beyond the metacarpophalangeal joints of the fingers, because movements of the flexor tendons alter the ligamentous tension (Fig. 4). Whenever some posterior displacement of the proximal fragment exists, reduction should be carried out by acutely flexing the wrist in the volar and ulnar position, while the operator's hand makes pressure over the snuff box. This usually replaces the proximal fragment in its proper position.

FIG. 4

Dorsal and radial views of the cast which is applied in fractures of the scaphoid. Wrist is in full radial flexion and dorsiflexed about thirty degrees. Thumb is held in full abduction and extension. Cast immobilizes entire thumb and the metacarpophalangeal joints of the fingers.

There is a marked difference of opinion as to the necessary period of immobilization. Destot [3] believes that ten days is sufficient; Speed [1] recommends seven to eight weeks; while Böhler [2] advises several months. There is a definite tendency among the more recent writers to lengthen the period of fixation. We have found that immobilization in the position here recommended should be maintained for a minimum of seven to nine weeks, depending upon the progress of the case and the age of the patient. Bony union will not occur under seven weeks and in many instances immobilization is necessary for twelve to fourteen weeks. It is better to err

on the side of too long immobilization. It has been our practice, however, to liberate the thumb at the end of five weeks, and, in retarded cases, to bivalve the cast after eight weeks, in order to begin baking and massage without disturbing the fracture. Anatomically and clinically, scaphoid fractures are very much like fractures of the femoral neck, and similar principles in treatment should be applied. This similarity arises from the fact that both fractures are intra-articular and devoid of periosteum, and that the proximal fragment in each case is deficient in blood supply.

FIG. 5

Diagram to show the drilling of fragments of the scaphoid. Note that the drill enters the scaphoid through its extra-articular, periosteum-covered surface at the approximate point of entry of the artery supplying this bone.

The necessity for exact reduction of the fracture with strong apposition of the fragments and long immobilization has been well shown by the interesting experiments in dogs carried out by Johnson[5]. He studied the healing process of the carpal scaphoid and showed that, although there is no periosteal callus, bony union takes place by a process which is similar to, but not as rapid as, repair of bone in the medulla of the diaphysis. In these experiments "approximation of the fragments was so close that mobility of displacement played no part in retarding union".

2. *Late Cases*

In the late cases with pseudarthrosis, or in those in which more than three weeks have elapsed before they are seen, these conservative methods are no longer of any value. In these patients we have carried out a simple surgical procedure which offers the hope of osseous union. In 1930, Schnek [6] recommended drilling of the scaphoid fragments under local anaesthesia by the subcutaneous method. A drill is introduced at the distal end of the bone near the entrance of its blood supply. It must be remembered that the arterial nourishment of the scaphoid is derived from a terminal arteriole which comes from the radial artery and enters near

the scaphoid tubercle, a fact which explains in part the tendency to non-union.

Using this principle of bone drilling, we have performed in seven cases a modified operation which we believe has several advantages over the subcutaneous route. A transverse incision an inch and a quarter long is made over the anatomical snuff box. A longitudinal cut is then carried through to the joint, retracting laterally the extensor pollicis brevis and medially the extensor carpi radialis. This gives an excellent exposure of the scaphoid. The drill is then introduced near the distal end of the bone, close to the point of entry of the arterial supply. Multiple drill holes along the long axis are made, which penetrate both fragments. At least five or six such holes must be made, a drill of No. 2 size being used (Fig. 5). In some cases, the proximal piece is found to be loose; and in these it is advisable before drilling to refreshen the fractured surfaces with a curet. Those fractures, however, which show good position and a strong fibrous union should not be disturbed, and should respond satisfactorily to simple drilling.

In cases where any dorsal displacement of the proximal fragment exists, the operator is able to move this piece into good anatomical position before carrying out the drilling. Obviously, the open method offers three major advantages: (1) a clear view of the operative field, (2) ability to refreshen the fractured surfaces when no fibrous union exists, and (3) proper reduction of the fracture.

Postoperatively, these cases are treated as recent fractures and immobilized in the manner already described, and for a similar period. Of seven cases in which this method of drilling was used, five healed with bony union, in spite of an average of one year's duration of the non-union. The two other cases showed some clinical improvement, due to firmer fibrous union.

In fractures which show marked comminution and deformity, or where definite lytic changes are evident, the drilling procedure is not advisable, because the anatomical irregularities present will sooner or later lead to traumatic arthritis. In spite of the poor results frequently reported, complete excision of both fragments is the ideal treatment in these cases. The failures reported may be attributed to incorrect postoperative treatment, because many surgeons allow motion immediately after operation. It is essential to immobilize the wrist in complete *ulnar* flexion for at least five to six weeks after total removal of the fragments, because this position allows the cavity to be filled with strong cicatricial tissue and permits the ligamentous and muscular structures to have their proper attachment. No instability of the thumb or tendency for radial deviation of the hand was noted in the four cases treated in this manner. One of these men was able to return to amateur boxing without any incapacity, and the others were strikingly free from symptoms.

We have removed the *proximal fragment only* in cases complicated by anterior semilunar displacement, feeling that too much injury had oc-

curred to the joint and, therefore, that immobilization was contra-indicated. Cotton and others, however, favor excision of the proximal fragment rather than total removal, because they claim that, although the wrist is left mobile, the thumb is weakened. This objection, however, is answered by the long postoperative fixation which we have recommended; whereas, in seven cases which came to us after removal of a single fragment, all presented some pain of the hand on pressure on the thenar region and forced dorsiflexion.

The argument that immobilization in radial flexion in recent fractures leads to a weakened grip is not true, according to our experience, since in no case has the wrist failed to return to a full ulnar flexion after the completion of physiotherapy. Moreover, the universal stiffness which is present following prolonged fixation in the Colles' fractures is absent after prolonged immobilization of fractures of the scaphoid.

CONCLUSIONS

1. Immediate diagnosis and splinting are necessary after injury to obtain osseous union by conservative treatment in intra-articular fractures of the scaphoid.

2. A method of fixation in plaster with the wrist in thirty to forty degrees of extension, complete radial flexion of the wrist, and with the thumb included in the position of extension and abduction, is offered as a rational manner of treatment, because it is founded upon sound anatomical principles.

3. Consistently good results have been obtained with immobilization in this position, when it has been continued for a sufficiently long period of time.

4. A bone-drilling operation is suggested which should heal the simple scaphoid pseudarthroses and should allow proper reduction in late cases.

5. In marked deformity, total excision of the scaphoid is recommended with postoperative immobilization for at least five weeks in complete ulnar flexion of the wrist.

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AUTOGENOUS BONE PEGGING FOR EPIPHYSITIS OF THE TIBIAL TUBERCLE

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Four cases of autogenous bone pegging of the tibial tubercle for epiphysitis, which did not respond to conservative treatment, have been completed. Previous operative attempts have consisted of splitting through the epiphyseal line, transference of the tibial tubercle *en masse*, excision of the tibial tubercle, pegging with ivory, the use of metal and wooden screws, and simple drilling through the epiphyseal line. Soule[1], in 1915, used a single autogenous bone peg and this procedure has been mentioned twice in the literature since that time.

The basic pathology responsible for epiphysitis has never been definitely proven. It is generally conceded that trauma is an important factor, and this trauma may be of either a direct or indirect nature. Circulatory defects undoubtedly are important also, but are probably closely allied with trauma. Bacterial invasion, late rickets, and endocrine disorders have been fairly well excluded as positive factors.

The general opinion regarding treatment is that conservative measures, such as strapping, rest, and protection, will always secure a good result, with restoration of the tibial tubercle to its normal position and appearance. That such is not always the case is shown by isolated reports of adults with typical symptoms of Osgood-Schlatter disease persisting over a great number of years. Brandes[2] reports a case in a man forty-five years of age. Soule[1] reports two cases in young men in the third decade, and Goldman[3] reports the case of a male seventy years old. In view of these reports and of the histories herein presented, the author is forced to assume that operative interference is justifiable in cases in which the symptoms have persisted for a long period or in those that do not respond rapidly to conservative treatment. The following case reports show that the patients did not readily respond to conservative treatment and that operative interference produced a very rapid and permanent subsidence of disability and symptoms.

CASE REPORTS

CASE 1. A boy, thirteen years of age, was first seen at St. Vincent's Hospital Clinic on September 23, 1932, complaining of a dull pain in the region of the right tibial tubercle, which had been present for the past year. There was slight thickening of the region and instability of the knee on weight-bearing, due to protective muscle phenomena. A loss of eight degrees' extension of the knee was present. During the previous year he had been treated by strapping and immobilization at another hospital.

He was admitted to the ward and, on October 7, 1932, a pinning of the right tibial tubercle was done. There was no postoperative reaction. The patient was kept in bed for one week, and was then allowed up on crutches. Three weeks after operation,

TABLE I

AUTOGENOUS BONE PEGGING FOR EPIPHYSITIS OF THE TIBIAL TUBERCLE

	Case 1	Case 2	Case 3	Case 4
Number of pins used	1	2	2	2
Preoperative condition	Irregular surface of tibial tubercle; very fine fragmentation overlying markedly widened epiphysis.	Discrete avulsed single fragment.	Discrete avulsed single fragment; irregular epiphyseal line in lower part.	Massive entire separation of tibial tubercle; markedly irregular epiphyseal line.
Location of grafts near upper tibial epiphysis	Yes	No	Yes	No
Complete obliteration of epiphyseal line of tubercle within one year	No	No	Yes	Yes
Complete obliteration of proximal epiphyseal line within one year	Yes	No	Yes	Yes
Graft in contact with loosened fragment	No	Yes	Yes	Yes
Homogeneous reossification with loosened fragment	No	Yes	Yes	Yes
Complete assimilation of graft within one year	No	Yes	No	Yes
Apparent absorption of graft across epiphyseal line with later reossification six weeks after operation	No	Yes	No	No
Absorption of portion of graft projecting into soft tissues	No	No	No	No
Calcification of soft tissue up to level of grafts and between grafts	Yes	Yes	Yes	Yes
Failure to regenerate site of removal of grafts	No	No	No	No
Decalcification of autogenous peg shortly after insertion with recalcification and reossification	Yes	Yes	Yes	Yes

the long plaster boot was removed and full weight-bearing was allowed. One month after operation, there was no pain or tenderness of the tibial tubercle. It was decreased in size and the patient had no discernible pathology in or about the knee joint. He has remained free of symptoms.

CASE 2. A boy, thirteen years of age, was first seen on January 7, 1932, at St. Vincent's Hospital Clinic. There was pain, tenderness, and swelling about the left tibial tubercle. Due to definite false motion palpated in the upper part of the tibial tubercle, operative interference with pegging was advised, but the boy was taken to another hospital and conservative measures were followed.

He returned to St. Vincent's Hospital Clinic on July 22, 1932, and an autogenous bone pegging of the tibial tubercle was done. A superficial wound infection (stitch abscess) developed on the fifth day, but healed rapidly. The patient was discharged walking and symptomless three weeks after operation. He has been followed and has had no recurrence of the tibial epiphyseal symptoms to date.

CASE 3. A girl, twelve years of age, appeared at St. Luke's Hospital Clinic on August 25, 1932, with a history of pain in the right tibial tubercle for one year following a fall. The examination showed no limitation of joint motion, but did show an enlarged, tender, mobile tibial tubercle and a partial loss of the power of extension, due to protection. Roentgenograms were taken and showed typical epiphysitis of the right tibial tubercle. The knee was strapped, but there was no relief whatever. Due to the history of prolonged pain, she was admitted to the Hospital.

On September 12, 1932, an autogenous bone-peg pinning of the right tibial tubercle was done. A long plaster boot was applied at the time of operation and the patient was up on crutches in twelve days. When the cast was removed eighteen days after operation, she had full extension and flexion to forty-five degrees. There was absence of all tenderness of the tibial tubercle. One month after operation, the knee was entirely negative for pathology.

About seven and one-half weeks after operation, the patient fell on the knee. Pain and tenderness immediately reappeared. Roentgenograms showed an apparent fracture of the distal tibial bone peg. No treatment was used except the decreasing of all activities. Pain and tenderness gradually subsided. Six weeks after the injury (thirteen weeks after operation) there were no remaining symptoms in the right tibial tubercle region.

CASE 4. A girl, twelve years of age, was seen at St. Luke's Hospital Clinic on May 12, 1932, with a history of pain in her left knee of one year's duration after bumping a door. A tender, thickened left tibial tubercle was found and she was strapped for six weeks without relief. Roentgenograms showed typical epiphysitis of the left tibial tubercle. Following restrapping, she remained free from pain for about one month; pain then gradually reappeared. On September 8, 1932, the condition was worse than when she was originally seen.

An autogenous bone pegging of the tibial tubercle was done on September 12, 1932, and a long plaster boot was applied. The boot was removed after two and one-half weeks. Three and one-half weeks after operation, the tenderness of the tibial tubercle was entirely gone; there was extension of the knee to 180 degrees and flexion to forty-five degrees. The patient was up with full weight-bearing, and was discharged. She has had no trouble since.

OPERATIVE PROCEDURE

A skin incision is carried downward over the lower third of the ligamentum patellae and tibial tubercle; then, swinging medially downward, the periosteum is split and laid back. Two match-stick bone pegs, four centimeters long, are cut with an electric saw; the central cut divides the two pegs and slants obliquely, so that each peg is larger at its base than at its tip (Fig. 1–A). The small end of each peg is cut obliquely

backward on its medullary surface to facilitate its entry into the hole drilled through the tibial tubercle into the tibial diaphysis. One hole is close to the proximal tibial epiphyseal plate, but does not touch it, and slants slightly upward and outward. The other hole is distal to the plate and slants slightly upward and inward. The diameter of these holes should be about equal to the thickness of the tibial pegs at their centers. The small ends of the tibial pegs enter the holes and are driven in so that the expanded bases hold the tubercle snugly against the tibial shaft. The sharp cortical margins of the square pegs crease the soft bone of the tubercle and tibia so that they are firmly retained in place and no rotation or other motion is allowed. Their angulation with each other also binds the tubercle fast to the tibia. Their upward slant causes any upward displacement of the tubercle to merely slide it closer in apposition to the tibial shaft. When the pegs are driven so that they set snugly, their projecting portions are cut off and the overlying tissues are closed with interrupted sutures.

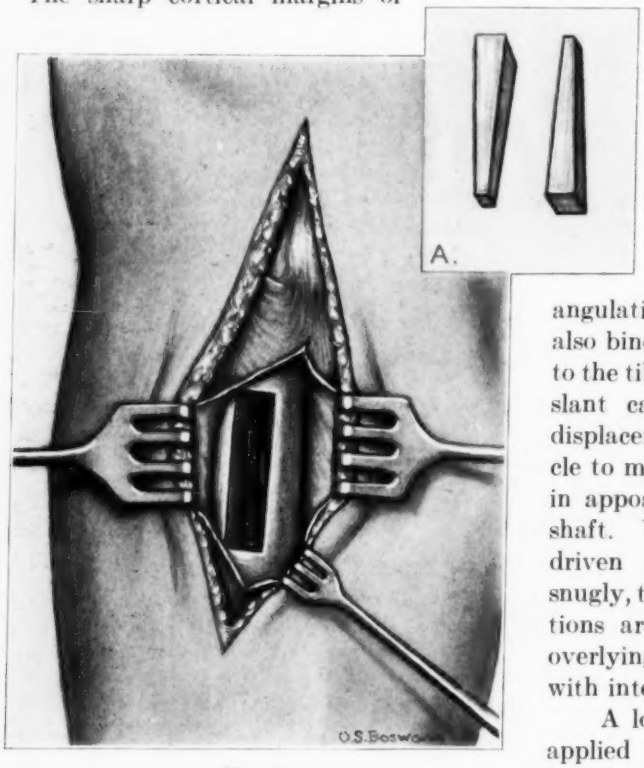

FIG. 1

A long plaster boot is applied and left in place for about two and one-half weeks. Following its removal, practically full joint motion is regained within three or four days and the patient is allowed up, walking. Total disability averages about three and one-half weeks.

A series of enlarged photographic prints of the roentgenograms of the tibial tubercles was made, without retouching, but with an effort to hold back the heavy shadows of the unimportant structures and bring into prominence all the details possible about the grafted area. A series of prints on each case is herewith presented, together with a table which represents a correlation of the facts from the study. In all the cases, fragments have been avulsed from the tibial tubercle. These varied in size from slight cortical chips in the first case to practically the complete

tibial tubercle in the last case. The condition existing preoperatively did not seem to have any effect on the end result. Proximity of the operative trauma and the autogenous graft quite definitely appeared to promote rapid and complete closure of the proximal tibial epiphyseal line, but in only half the cases caused a complete obliteration of the epiphyseal line of the tibial tubercle. In cases where the epiphyseal line of the tubercle was not obliterated, the graft reossified directly across it, in each instance forming a bony bridge from tubercle to tibial shaft. Where the grafts pierced or were in contact with the fragments, homogeneous ossification of fragments, grafts, tubercle, and tibia occurred. In one instance, where the grafts did not contact the fragments, the fragments ossified as a separate mass. However, it is noteworthy that the treatment of this case was clinically successful, probably due to reattachment of the patellar tendon to the graft by fibrous tissue. Complete assimilation of the entire graft occurred in half of the cases within one year. In the other cases the graft reossified but a distinct shadow was still evident, although apparently the bony structure was continuous with the surrounding structure. In one instance, Case 2, there was apparent complete absorption of the graft where it passed through the epiphyseal line. This area later became reossified. There was no instance of absorption of ends projecting into the soft tissues above the level of surrounding bone. In all these cases, the soft tissues ossified up to the level of the tips of the grafts. The small defects left by removal of the grafts completely regenerated in every instance within one year. The grafts themselves became markedly decalcified shortly after their insertion, and when they again became calcified it was with a new and distinct bony structure.

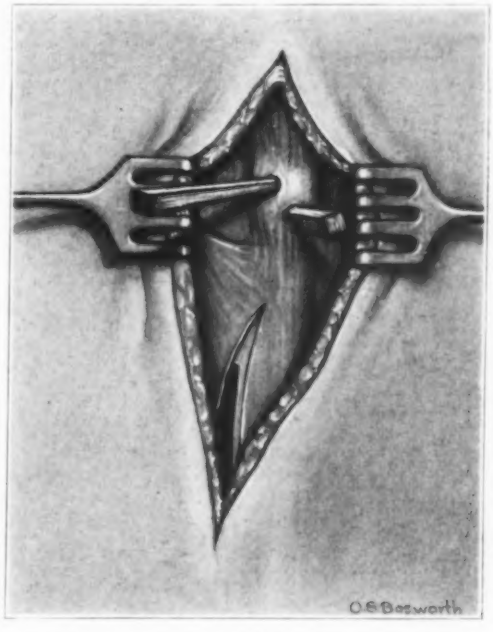

FIG. 2

CONCLUSIONS

1. Operative trauma alone, such as merely drilling across the epiphyseal line at the tibial tubercle, may fail to cause closure thereof in half or more of the cases.

2. Statistics show that operative procedure of a similar nature is

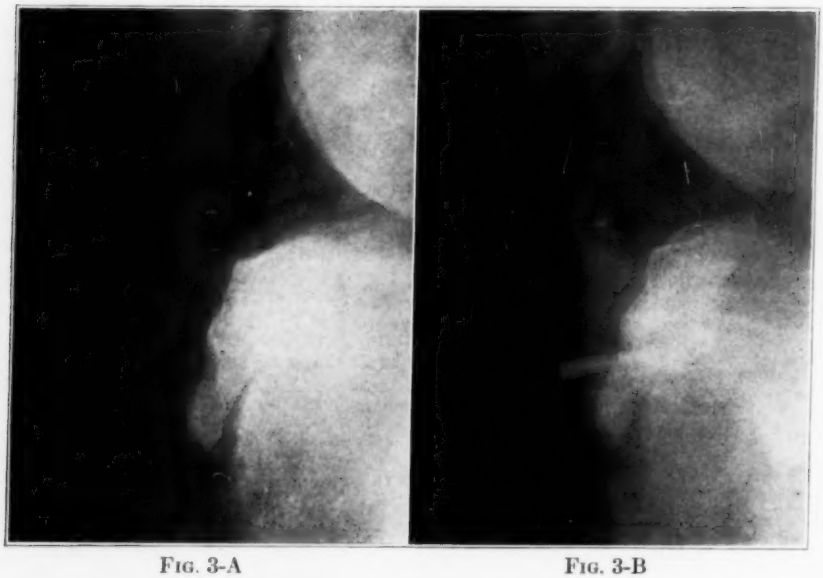

FIG. 3-A FIG. 3-B

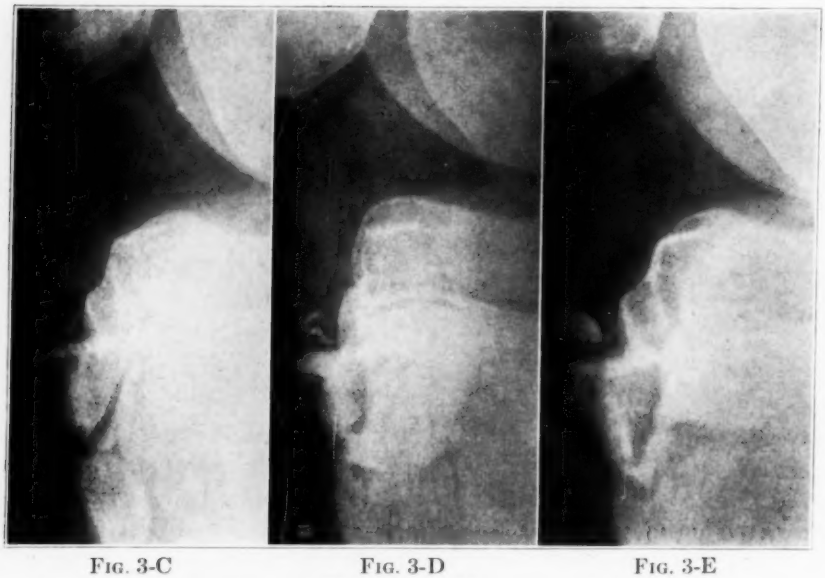

FIG. 3-C FIG. 3-D FIG. 3-E

CASE 1. L. M.

FIG. 3-A. October 5, 1932. Before operation. Epiphysitis with apparent avulsion of ligamentum patellae from roughened area, superficial surface of tibial tubercle.

FIG. 3-B. October 13, 1932. After operation. Single autogenous bone peg placed in contact with the distal surface of the very faintly avulsed fragments.

FIG. 3-C. December 13, 1932. Bone peg decalcifying and definitely not in contact with avulsed fragments.

FIG. 3-D. February 24, 1933. Autogenous peg reossified, epiphyseal line becoming obliterated, and avulsed fragments becoming more heavily deposited with calcium.

FIG. 3-E. August 29, 1933. Autogenous peg reossified and epiphyseal line almost closed. Avulsed fragments reossified into one mass within ligamentum patellae.

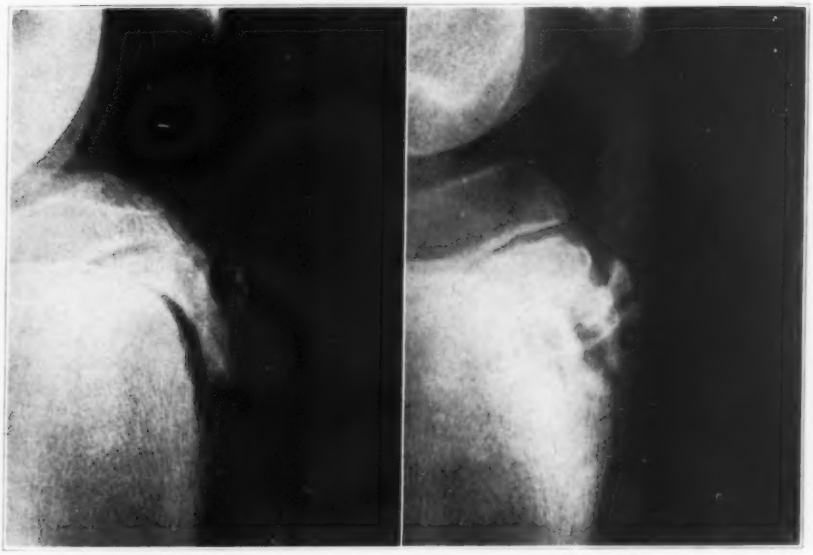

FIG. 4-A FIG. 4-B

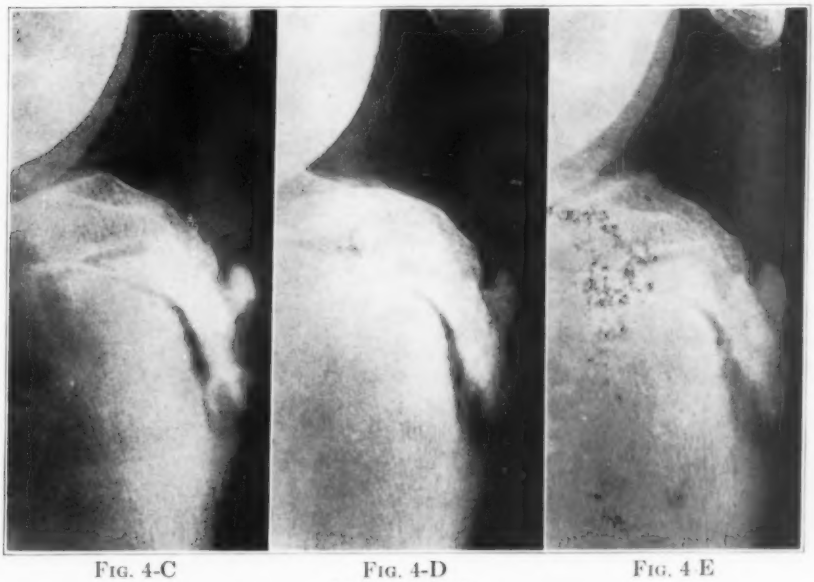

FIG. 4-C FIG. 4-D FIG. 4-E

CASE 2. E. B.

FIG. 4-A. July 1, 1932. Before operation. Epiphysitis of tibial tubercle with avulsion of portion thereof.

FIG. 4-B. September 9, 1932. Two autogenous pegs in place and avulsed fragment already ossified thereto. Autogenous pegs being absorbed where they cross the epiphyseal line.

FIG. 4-C. October 7, 1932. Avulsed fragment solidly ossified to tibial tubercle. Showing complete calcium absorption of the autogenous pegs at point where they cross the epiphyseal line.

FIG. 4-D. December 12, 1932. Showing beginning of ossification of bone-peg structures where they cross the epiphyseal line.

FIG. 4-E. February 24, 1933. Complete ossification of avulsed fragment to tibial tubercle and of bone pegs crossing the epiphyseal line, with practically complete closure of epiphyseal line.

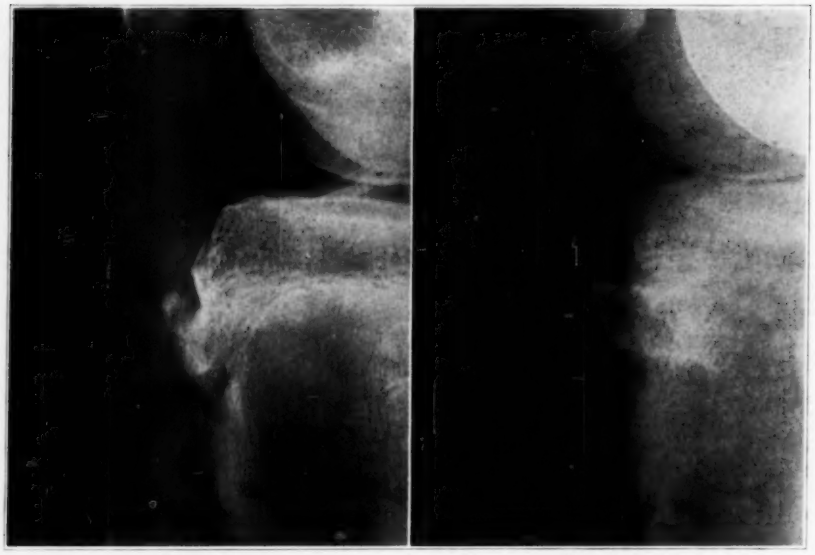

FIG. 5-A FIG. 5-B

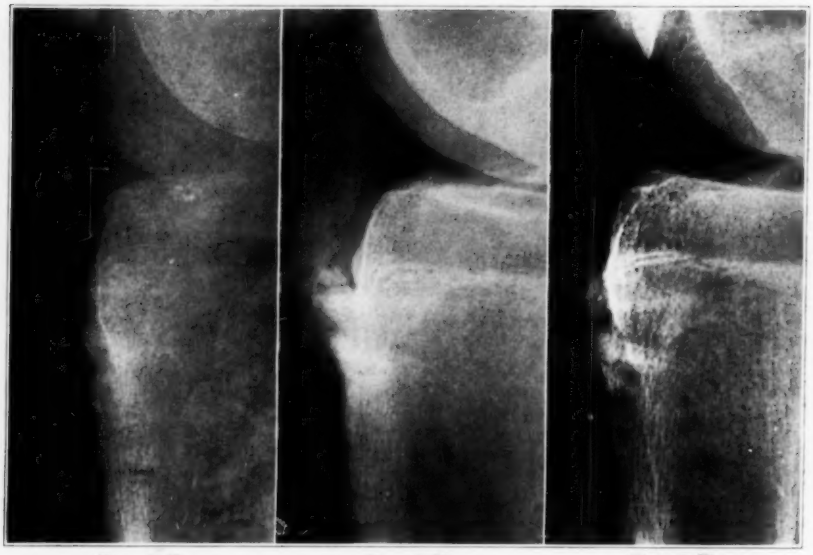

FIG. 5-C FIG. 5-D FIG. 5-E

CASE 3. J. L.

FIG. 5-A. Before operation. Showing epiphysitis of tibial tubercle with avulsion of small fragment.

FIG. 5-B. October 1, 1932. Two autogenous bone pegs crossing epiphyseal line and in contact with fragment. Slight defect below bone pegs shows point of removal of bone for autogenous grafts.

FIG. 5-C. December 16, 1932. Showing decalcification of bone pegs and well developed union of avulsed fragment to proximal peg. Defect in tibial shaft at point of securing of grafts is disappearing.

FIG. 5-D. January 24, 1933. Bone pegs and fragment reossified *en masse*. Epiphyseal line closed.

FIG. 5-E. July 25, 1933. Showing end result with all structures reossified, excellent bony detail. The defect in shaft at point of securing graft has entirely disappeared.

FIG. 6-A FIG. 6-B FIG. 6-C FIG. 6-D

CASE 4. G. A.

FIG. 6-A. June 23, 1932. Before operation. Epiphysitis of tibial tubercle with practically complete loosening thereof.

FIG. 6-B. October 1, 1932. Showing two autogenous bone pegs in place, moderate calcium absorption of same, and defect in tibial shaft below the lesion where pegs were secured.

FIG. 6-C. December 10, 1932. Reossification of bone pegs and nearly complete closure of epiphyseal line of tibial tubercle have occurred. Defect in tibial shaft below the lesion is healing.

FIG. 6-D. August 15, 1933. Complete reossification of tibial tubercle and bone pegs has occurred, with their assimilation in bony structure to the tibial shaft. The defect in the tibial shaft at point of removal of grafts has disappeared.

not new, that the results are good, and that, in cases of long standing, operative interference is a logical procedure.

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TUBERCULOUS RHEUMATISM

A Résumé*

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During the past thirty-five years, considerable attention has been given in the foreign literature to a condition known as "tuberculous rheumatism", an entity which has never been recognized in this country. The term has been applied to various cases of polyarthritis—acute, subacute, and chronic—in which the etiology is thought to be tuberculosis. The concept of "tuberculous rheumatism" implies a relationship with what is called tuberculous arthritis, acute rheumatic fever, atrophic infectious polyarthritis, and hypertrophic arthritis; yet it is distinct from these in the minds of the proponents of this condition as an entity. In order to avoid confusion, it may be well to define these terms at the outset.

Tuberculous arthritis is the name applied to the usual type of tuberculous joint disease. It is characterized by pain, swelling, and stiffness of the joint, with accompanying local warmth and atrophy of the surrounding tissues. Redness may or may not be present; in the late stages it is usually lacking. The condition is indolent, characterized by remissions and exacerbations, and is usually progressively destructive, unless the process is checked by placing the joint at rest, either by some form of splinting or by arthrodesis. The onset is usually gradual, but the condition often follows injury to the joint or an infectious process elsewhere in the body. Various observers have reported an accompanying visceral tuberculous lesion in thirty-five to fifty per cent. of their cases. The method of infection is probably through the blood stream from some distant latent or active tuberculous focus. The positive diagnosis of the condition rests on the finding of viable Koch's bacilli in the joint fluid or synovial membrane, as shown by inoculation of guinea-pigs and the demonstration of tuberculous tissue,—that is, of epithelioid cells and lymphocytes in characteristic configuration, with or without the presence of necrosis and foreign-body giant cells. The roentgenograms are not characteristic in the early cases or in cases in which there is advanced destruction. Usually, in cases of moderate duration, there is atrophy of bone, marginal erosion of bone, and interruption of the articular cortex. There may be marked haziness of the joint and definite synovial thickening. The joint space is usually well preserved until the late stages of the disease, because of the resistance of the articular cartilage, even though it may be detached and necrotic, to the action of the tuberculous infecting agent.

Ordinarily, tuberculous arthritis involves a single joint. The reason

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for this is not well understood, but it has come to be recognized as a characteristic of the condition. In some cases, however, two or more joints may be involved. It is not uncommon, for example, to find tuberculous arthritis present in a hip and in the spinal column, or in a knee and ankle. Ghormley and one of us (E. A. B.), in a series of 168 cases of tuberculous arthritis of the knee, noted tuberculous involvement of two joints in twenty-two cases (13.1 per cent.), and involvement in more than two joints in nine cases (5.4 per cent.). Nevertheless, when more than three joints are the seat of arthritis, the probability of tuberculosis being the etiological agent is considered remote.

The first description of what is known to be chronic tuberculous arthritis was given by Wiseman in 1676. His treatise has become a classic on this subject, but in the light of present knowledge it cannot be accepted as having presented a characteristic picture. Wiseman's term "white swelling" describes the condition which is seen in many cases of chronic tuberculous arthritis, but it does not take into account the fact that redness is often present, usually in the earlier stages, and that non-tuberculous arthritis may at times present a similar picture. The term "white swelling", however, may be used conveniently to designate the usual, though perhaps not entirely characteristic, picture of tuberculous disease of joints.

The condition which is called rheumatic fever is an acute infectious process of unknown etiology in which numerous joints are attacked successively. There is rapid spread of the swelling, redness, pain, and tenderness from one joint to another. Coincidentally, there is high fever, malaise, anorexia, and chills. The acute process extends over a period of about six weeks and is usually followed by complete restoration of the normal appearance and function of the joint. The general systemic effects, however, are not so transient. There is often subsequent cardiac impairment in the form of myocarditis or endocarditis. Roentgenograms are negative except for the evidence which they give of swelling of soft tissue. Local collections of round cells and fibroblasts, the so called Aschoff's nodules, have been demonstrated in the heart muscle and in other tissues and are considered by some to be characteristic pathological manifestations of the condition.

Chronic atrophic polyarthritis (infectious, rheumatoid, proliferative) is a slowly progressive, usually symmetrical type of involvement of joints, seen most often among patients who are less than forty years of age, and is characterized by associated muscular atrophy, loss of weight, anorexia, anaemia, and vasomotor instability. Its onset is occasionally acute, with subsequent persistent joint disability, but more often the onset is gradual and unaccompanied by fever and malaise. In the chronic stage, there are frequent exacerbations of symptoms, with increased pain, swelling, and joint disability. Redness of the joints is variable. The roentgenographic evidence of the condition consists of atrophy of bone, narrowed joint space, and late development of osteophytic lipping. Pathologically, there is synovial proliferation, destruction of cartilage, and a tendency to

ankylosis in the late stages. On microscopic examination, perivascular collections of lymphocytes have been noted in the synovial membrane, the adjoining bone marrow, and adjacent muscular and fibrous tissues. The cause of the condition is unknown, but numerous observers have isolated organisms, chiefly streptococci, from the blood stream and from the joint fluid and synovial membrane in these cases. It is generally believed that distant foci of infection may play a part in the etiology of this disease.

Chronic hypertrophic polyarthritis (senescent, degenerative, osteoarthritis) is characterized by its appearance usually after the age of forty years, inevitably after sixty; the patients are not affected by concomitant loss of weight, anaemia, anorexia, muscular atrophy, or vasomotor instability. It is usually less symmetrical than the atrophic type, and localizes in certain favorite sites,—namely, the distal interphalangeal joints, the cervical or lumbar but generally not the thoracic portion of the spinal column, the knees, shoulders, and hips. The roentgenographic picture consists of the early production of osteophytic lipping and a tendency to bony hypertrophy rather than atrophy. Pathologically, there is primary degeneration of the joint cartilage, thickening and eburnation of bone, and absence of ankylosis. Microscopically, the cartilage is fibrillated, the bone is hypertrophic, and there are fibrotic changes in the synovial membrane. Infection probably plays a much less important part in the etiology of this type of arthritis. The mechanism is thought to be a degenerative change, due to old age and trauma.

In this country, neither the atrophic nor the hypertrophic type of chronic polyarthritis is thought to be of tuberculous origin, because repeated microscopic examinations in such cases have failed to reveal the changes considered typical of tuberculosis, and inoculation of guinea-pigs with material derived from these joints has given consistently negative results. The same conclusions have been drawn from studies of cases of acute rheumatic fever. In Europe, on the contrary, cases which we would have included in any of these three categories have been sometimes considered to present evidence of tuberculous infection. The term "tuberculous rheumatism", as used by its proponents, designates a form of polyarticular disease which presents no objective similarity to ordinary tuberculous arthritis, but which may so closely resemble the other three types of disease of the joints that it is clinically indistinguishable. It is nevertheless considered to be a manifestation of a tuberculous infection somewhere in the body, due not necessarily to the intra-articular presence of viable bacilli of tuberculosis, but perhaps to their toxins or to organisms of tuberculosis which are too attenuated to produce anything other than a non-specific inflammatory reaction in the joint.

HISTORICAL REVIEW

Bonnet, in 1845, noted that frequently joints which were the seat of chronic atrophic polyarthritis presented a gradual change to "white

swelling". In 1864, Charcot described a large number of patients with polyarthritis (unclassified) who later succumbed to pulmonary tuberculosis. Lancereaux, in 1871, described a patient with tuberculosis of the knee joint, who previously had had generalized arthritis which disappeared except for localization of arthritis in the knee. Gubler, in 1874, suggested to his student, Powel, the subject of "articular pseudo-rheumatism" in patients who presented the general appearance of, and sometimes the clinical findings of, tuberculosis. He stressed the frequent cardiac involvement in the disease and denied the necessity of finding definite tubercles in the joints in order to prove the tuberculous etiology. Laveran, in 1876, and later Pollosson, reported the finding of typical tuberculous pathological changes in the joints of patients with chronic atrophic polyarthritis. In 1878, Bouilly noted the development of "*tumeur blanche rhumatismale*" among children following attacks of atrophic arthritis. Landouzy, in 1880, remarked on the subject of "*tuberculose atypique*" in reference to such cases of polyarthritis. Grocco, in 1892, led the way to further clinical and laboratory studies in these cases when he insisted that patients with tuberculosis might present a form of arthritis unassociated with tubercles or abscess, similar to that which is now called atrophic arthritis. It remained for Poncet, of Lyon, in 1897, to describe the clinical picture of the "*rhumatisme tuberculeux*" with which his name is now associated.

Poncet treated a suppurating tuberculous hip joint of a young patient who also had pain and swelling of the wrist and interphalangeal joints. In addition, there was a pulmonary lesion which was thought to be tuberculous. After admission to the hospital, an acute flare-up of arthritis developed in the knees and feet. This subsided in a few weeks, but was followed by additional attacks of polyarthritis, apparently of the atrophic type. Poncet's reasoning was that since there was no evidence of any other infection in the body, and since the patient had definite tuberculosis of the hip and probably of the lungs, the likelihood was that all the lesions of the joints were due to the same cause. He argued that, if acute arthritis develops following gonorrhoeal infection, it is presumed that the condition of the joint is gonorrhoeal, although there may be no bacteriological evidence to support this view. Why not, then, with a known tuberculous focus in the body, consider involvement of the joints of such an individual as the result of this infection, even though there be no bacteriological or pathological evidence?

Following this initial observation, Poncet attempted to find in the clinics of Lyon other cases of polyarthritis which might be tuberculous in origin. He noted the similarity in the general bodily appearance of patients with atrophic polyarthritis to patients with definite pulmonary tuberculosis. He observed that very often the two diseases were coincident. He noted, further, the large number of elderly persons with pulmonary tuberculosis who had definite multiple arthritis (hypertrophic). Although Poncet could not satisfy himself as to any clinical distinction

between the cases which he thought to be tuberculous polyarthritis and those in which there was no evidence of tuberculosis, he nevertheless felt that there was a definite relationship between the two diseases.

Experimentally, Poncet noted the development of arthralgia among patients who received subcutaneous injection of Koch's bacillus serum. He also noted that patients with lupus, treated by tuberculin, often had pain and swelling in several joints. He observed, furthermore, that in cases of arthritis there was a focal reaction in the involved joints on subcutaneous injection of tuberculin. He believed that these findings were suggestive of a tuberculous etiology in these cases of both atrophic and hypertrophic polyarthritis. The frequent finding of positive tuberculin skin reactions in Poncet's cases was also considered as evidence for this conclusion. Poncet was able, in rare cases, to culture Koch's bacilli from the joint fluid. Roentgenographically, he could find no distinction between the cases which he considered tuberculous and other cases of polyarthritis. After several years of observation, during which pathological examinations and inoculations of guinea-pigs consistently gave no evidence of tuberculous infection in the joints of patients who had atrophic and hypertrophic polyarthritis, Poncet nevertheless came to the conclusion that many of these cases were similar to cases of tuberculous arthritis in that they were merely different manifestations of the same disease. He felt that the latter type of reaction was due to the presence of virulent bacilli of tuberculosis in the joint; whereas the polyarticular variety was the result of either a tuberculous toxin liberated from a distant focus or of the action of attenuated organisms present in the joints themselves.

Poncet described two forms of "tuberculous rheumatism": (1) acute or subacute, including the extremely rare cases (described by others) in which typical tubercles can be found in the joint tissues of these patients with polyarthritis, and the more common type of "*tuberculose inflammatoire*" in which there are neither tubercles nor bacilli present; (2) chronic, including those cases which we would classify as atrophic and hypertrophic forms of polyarthritis and which usually present no specific evidence of tuberculosis. Poncet's diagnoses of cases of "tuberculous rheumatism" were based on associated visceral tuberculosis (active or inactive), a tuberculous family history, or the presence of a true tuberculous joint in any patient before, coincident with, or following a polyarthritis (any type). Poncet was so struck with the relationship between tuberculous disease and many cases of polyarthritis that he is quoted as having stated that "in the presence of rheumatism, that which one should demonstrate in the very first place is that it is not tuberculous".

Poncet attributed no importance to trauma in the etiology of "tuberculous rheumatism" and stated that he had seen the disease spread from one member of a family to another. He furthermore stated that he had seen the lesions of the joints disappear with the onset of hemoptysis in cases with associated pulmonary tuberculosis.

Poncet described cases of "tuberculous rheumatism" in which the

condition of the joints varied from simple arthralgia and hydrops to more severe forms of arthritis. Varieties in which there were dislocation, ankylosis, deformity, and osteoporosis were mentioned by him in his writings. In his enthusiasm, he believed "*spondylose-rhizomélique*"—Marie-Strümpell's chronic deforming spondylitis, involving the hips and shoulders—to be a part of the picture of "tuberculous rheumatism". He described polyneuritis, myositis, fibrositis, and cardiac involvement in some of these cases, and even expressed the opinion that this generalized, attenuated tuberculous infection was responsible for such conditions as erythema nodosum, Dupuytren's contracture, Madelung's deformity, and hallux valgus.

Poncet's assertions were met with heated opposition, especially by the School of Paris, but they were convincing enough to initiate feverish investigation of the subject. Courmont, Dor, Arloing, Lannelongue, Dieulafoy and Griffon furnished laboratory and experimental support of Poncet's hypothesis. Achard, Barbier, F. Bezançon, Dieulafoy, Widal, and Milian, all of Paris; Pic, Barjon, Teissier and Roque, and Patel, of Lyon; and the Germans—Melchior, Menzer, Esau, Froehlich, Mohr, Buschke, Burkhardt—corroborated the clinical findings. On the other hand, Barth, Bérard, Broca, Souques, Verhoogen, and many others were vehement in their opposition.

For ten years the controversy was waged in the French and German literature. The concept of "tuberculous rheumatism" was furthered by the reports of Alamartine, Bentz, Bernard, Beutter, Chalier, Trébeneau, Delore, Galliard, Gauthier, Hollós, Mailland, Rivière, Thévenot, and others. Among the English writers there appeared summaries of Poncet's work by Lyle and by Thomson, and suggestive cases were presented with no great enthusiasm by Edsall, Edsall and Lavenson, Raw, and Weber. In 1915 there was a sudden end to this argumentation. Scattered reports by Pellé, Betchov, Duvernay, Findlay, Oddo and Giraud served as reminders of a subject which had failed to furnish sufficient evidence for widespread acceptance.

Since 1925, the problem has again been prominent. Recent researches have induced many modern writers, especially of the School of Paris, which had originally frowned on Poncet, to advocate acceptance of the syndrome of "tuberculous rheumatism". The work of Reitter and Löwenstein, Fontes, Vaudremer, Calmette, and Valtes has thrown a new light on the subject of tuberculous arthritis. Bezançon, M.-P. Weil, Delarue and Oumansky, Harvier, Rachet and Lemaire, Ory, Frugoni and Persico, Mollard and Charleux, Paisseau and Oumansky, Lerner, Cooperman, Pic and Chapuy, Rouillard, Carnot and Terris, van Breemen, J. Weill, Wilkinson, and many other writers have presented modern clinical and laboratory evidence. With this recent mass of corroborative observation tending to sway the balance in favor of acceptance of "tuberculous rheumatism" as an entity, it may be well to summarize the findings to date and attempt to form some sort of evaluation for future guidance.

IDEAS ON PATHOGENESIS

Since the time of Poncet, the interest which has been taken in the subject of tuberculous rheumatism has led to the development of numerous theories as to its pathogenesis. These may be reviewed briefly:

Diffusible Toxins: A number of observers have expressed the opinion that the lesions of tuberculous rheumatism are due entirely to toxic products of bacilli of tuberculosis liberated from some distant focus into the blood stream. Duvernay and Chalier have expressed this opinion in their writings. Auclair and Rodiguer, Bruault and Coureaux, and Letulle believed that only inherent toxins of Koch's bacilli could cause typical caseous or nodular lesions, thus accounting for the rarity of specific findings in tuberculous rheumatism.

Action of Attenuated Bacilli: It has been felt by some writers that the presence of attenuated bacilli in the joints is a necessary prerequisite to the development of tuberculous rheumatism. Griffon, Mauclair, J. Weill, Ory, and van Breemen are among the proponents of this theory. They believe that these less virulent organisms can produce only a nonspecific inflammatory reaction. The latter two observers feel that the reaction of the joint to tuberculous infection varies with local resistance.

Either Diffusible Toxins or Attenuated Bacilli: This theory, proposed in the description of tuberculous rheumatism by Poncet and Leriche in 1909, after twelve years of study, has been accepted by Delore and the large majority of observers.

Allergy: The idea that the lesions of tuberculous rheumatism are due to hypersensitivity created in the structures of the joint by a primary and evanescent tuberculous infection which is later lighted up by a reinfection, has been propounded by Bezançon, Bernard, and Célice, Nové-Josserand, Reitter, J. Weill, Frugoni and Persico. The last two observers stated that "the pathogenesis of infectious rheumatism and tuberculous rheumatism in particular is dependent to a large extent on a tissue hypersensitivity created in the body by the action of a septic focus in such a way that it manifests itself as a diffuse nodular reaction of vascular and connective tissue". They felt, along with many others, that cases of tuberculous polyarthritis in which definite specific lesions could be demonstrated should not be included in the category of tuberculous rheumatism. They believed that there was a definite arthrotropism of certain tuberculins just as Rosenow and others have shown the elective localization powers of various streptococci. Le Flock stated that tuberculous rheumatism was due to a sensitization of joints by tuberculous toxins. Subsequently, any type of antigen—streptococcic, tuberculous, etc.,—may cause polyarthritis. The theory of allergy is based on the observation of Weintraub in 1913 of the similarity between the lesions of acute rheumatic polyarthritis and those of serum sickness. Numerous researches have tended to advance the importance of this theory, including those of Herry, and of Swift and Boots on articular reactions to intravenous in-

jections of streptococcic antigens into animals previously sensitized, and of Swift, Birkhaug, Small, and Wilson on cutaneous reactions of patients with polyarthritis. None of these observers, however, has applied his findings to the subject of tuberculous rheumatism.

Ultravirus of Tuberculosis: It is believed by Oumansky, and by J. Weill, following the work of Fontes and Vaudremer, that there may exist a form of tuberculous infecting agent which is not demonstrable microscopically and which would account for the absence in the joints of bacilli of tuberculosis and for the absence of specific pathological reactions of tuberculosis. They believe that the change from what appears to be atrophic arthritis to typical tuberculosis in a joint may be due to the transformation of the ultravirus within the joint to true bacilli of tuberculosis.

Trophic Change: It is believed by Teissier and Roque and others that chronic polyarthritis (any type) may be due to a central or peripheral involvement of the nervous system by tuberculous infection, with resultant trophic changes in the joints. Roger, Froment, and Ferru have described polyneuritis in phthisical cases with associated polyarthritis.

CORROBORATIVE EVIDENCE

Certain observations before the time of Poncet and much work done on the subject of tuberculous rheumatism since the introduction of this subject to the literature have tended to sustain this diagnosis. The findings which seem to corroborate Poncet's conception of tuberculous polyarthritis will be summarized:

Family History: The finding of a family history of tuberculosis in cases of polyarthritis of various types has been considered suggestive of the etiology of the lesions in the joints. Fuller, in 1860, reported a series of cases of polyarthritis of various types, in twenty-three per cent. of which there was a history of familial tuberculosis. Charcot reported similar findings. Valentin noted a family history of tuberculosis in forty per cent. of his patients with chronic polyarthritis (unclassified). Stewart observed that pulmonary and other forms of tuberculosis appeared to be more frequent in families of sufferers from atrophic polyarthritis than from other non-tuberculous diseases. In his series of forty cases, however, there was a positive history in only three (7.5 per cent.). Souques and Cawadias found a family history of tuberculosis in nine (36 per cent.) of twenty-five cases of generalized chronic arthritis (atrophic).

Associated Tuberculosis: A large number of observers have reported the finding of associated visceral tuberculosis in a high percentage of their patients with acute and chronic forms of polyarthritis. Trébeneau investigated 200 patients with pulmonary tuberculosis. Of these, nineteen (9.5 per cent.) had previously had arthralgia and fifteen (7.5 per cent.) had had definite pain and swelling in several joints. Poncet stated that from five to seventeen per cent. of his patients with active pulmonary tuberculosis and twenty per cent. of his patients with chronic inactive pulmonary tuberculosis had had at some time tuberculous rheumatism. He pointed

out, conversely, that, in twenty per cent. of his cases of chronic arthritis (presumably atrophic), tuberculous lesions developed elsewhere in the body. Tommasi, in the hospitals for tuberculous patients in Florence, found that twenty-three per cent. of the patients had suffered from various forms of polyarthritis, and that for twenty per cent. this had been the prelude to hemoptysis or some other evidence of pulmonary tuberculosis. Luc and Olivier obtained similar results in investigating their cases. Merson found one case of polyarthritis in every six cases of tuberculosis (16.6 per cent.). Riccitelli, Leuchtemberger, Minerbi and Caretti, Passigli, and Crenet found signs of tuberculosis elsewhere in the body in a large percentage of patients with acute rheumatic fever. Trousseau noted in the same patients white swellings, generalized arthritis of various forms, and pulmonary tuberculosis. Poncet found that forty per cent. to fifty per cent. of the patients with chronic deforming arthritis of old age (hypertrophic arthritis) had or later acquired tuberculous lesions of varying activity elsewhere in the body.

General Appearance and Course of the Disease: Numerous writers have noted the similarity between the rheumatic and the phthisical habitus. Both polyarthritis and visceral tuberculosis seem most often to afflict individuals with feeble constitutions, who are susceptible to the ill effects of exertion, cold, and humidity. These usually occur among individuals of the poorer class who live under conditions of sanitation and personal hygiene that are none too good. The patients are commonly undernourished, pale, and easily fatigued. Pemberton stated that "many cases of atrophic arthritis have the general bodily configuration of individuals predisposed to phthisis". Swift found rheumatic fever and tuberculosis comparable in the following ways: In both, the influence of heredity and environment are factors; both are localized manifestations of a generalized infection; both are more common as acute generalized infections in young people, tending toward allergic localization in later years,—in the lungs in the case of tuberculosis, in the joints in the case of rheumatic fever; they both have proliferative and exudative forms, and both present miliary collections on microscopic examination,—Aschoff's nodules in rheumatic fever, tubercles in tuberculosis. Wilkinson stated that he had observed numerous affinities between cases of atrophic polyarthritis and tuberculosis, and that he saw no reason why a case of polyarthritis in which there was no specific pathological change could not possibly be tuberculous in nature.

Symptomatology and Physical Findings: Occasionally one observer or another has suggested some clinical means of distinguishing tuberculous rheumatism from other forms of polyarthritis. Bezançon, Bernard, and Célice pointed out the absence of cardiac involvement among patients with tuberculous rheumatism. This has been corroborated by Laederich, Mamou, Arager, and Léonard. Ory has claimed that tuberculous rheumatism attacks fewer joints than acute rheumatic fever or chronic atrophic polyarthritis, and that tuberculous rheumatism tends to strike one

joint heavily and the other joints lightly. Bezançon felt that the joints in tuberculous rheumatism were more likely to heal spontaneously and without residua than the joints in atrophic polyarthritis. Van Breemen expressed the belief that the rectal temperature was higher in tuberculous rheumatism than in atrophic polyarthritis and that crepitation in the joint was of a different nature, but the latter method of distinction between the conditions was not made clear. This observer stated that, in about 3,000 cases of polyarthritis which he had seen in the past twenty years, from five to ten per cent. should be given the diagnosis of tuberculous rheumatism. Most writers agree with Bezançon, M.-P. Weil, Delarue, and Oumansky that the transformation of joints which formerly were the seats of atrophic polyarthritis into typical "white swellings", the specificity of which may be proved by biopsy or by guinea-pig inoculation, is highly suggestive of the tuberculous nature of the primary polyarthritis. Teissier and Roque, Frugoni and Persico, Coste, and Pic stated that tuberculous rheumatism was more common than was realized, but they were unable to offer any distinguishing clinical characteristic from other forms of polyarthritis.

Van Breemen often has seen tuberculous pleurisy disappear on the development of a polyarthritis. Bezançon and Jacquelin, and Sergent have noted improvement in the polyarthritis with the arrest of associated pulmonary lesions effected by pneumothorax.

Roentgenographic Evidence: Some observers have reported roentgenographic findings which they consider characteristic of tuberculous rheumatism. Bérard and Destot noted islands of decalcification at the heads of the phalanges, sometimes extending to the cartilage and penetrating and destroying it. Pic and Chapuy stated that in chronic cases characteristic roentgenograms gave evidence of deformities of the articular surfaces, loss of cartilage and of joint space, and the presence of zones of decalcification. Rouillard observed in early cases periarticular swelling only and in later cases destruction of joints. Babonneix and Mornet reported a case in which there was a family history of tuberculosis and a history of quiescent pulmonary tuberculosis. Acute polyarthritis developed and there was uncertainty as to its origin until a roentgenogram of the carpal region gave evidence of "typical tuberculous destruction". These observers concluded, therefore, that the case must have been one of tuberculous rheumatism.

Pathological Evidence: The finding of typical tuberculous pathological lesions in cases of tuberculous rheumatism has been so rare that their very presence is looked on by most investigators as being evidence contradictory to the diagnosis of tuberculous rheumatism and in favor of the diagnosis of tuberculous arthritis. Laveran and Pollosson reported the finding of tubercles in the joints of one or two patients who had polyarthritis. In a case of polyarthritis, following biopsy of both knees, Elbe reported inflammatory tissue in one and typical tuberculous tissue in the other. Carnot and Terris found inflammatory tissue with "characteristic giant cells". Melchior was occasionally able to identify a characteristic

tuberculous lesion. After biopsy in a series of twelve cases of atrophic polyarthritis that were thought to be of tuberculous nature, Ory found only one case which presented typical tuberculous pathological change. Cooperman reported the histopathological findings in four cases of atrophic polyarthritis associated with pulmonary tuberculosis. In two of these cases, on examination of the tissue removed from the knee joints, typical tuberculous pathological change was found.

It is rather generally believed that the finding of definite tuberculous pathological change in the joints of patients with polyarthritis is evidence of superinfection by tuberculous organisms in a case of ordinary non-tuberculous polyarthritis. Poncet and Leriche stated that the pathological changes of tuberculous rheumatism represented a stage of transition between the ordinary inflammatory changes of arthritis and typical tuberculous arthritis. In some of their cases they demonstrated perivascular collections of cells; in others, intimal proliferation of the blood vessels. Usually there were no giant cells, but when they were present these observers interpreted them as representing a gradual transformation from non-specific inflammatory tissue to tuberculosis. In Cooperman's other two cases, he found swelling and vacuolization of the intima of the blood vessels, giant cells, necrosis, and endothelial cells.

Letulle, Bezançon, and Weil noted what they believed to be similarity between the submiliary nodules (Aschoff's bodies) found in the heart muscle in rheumatic fever and typical tubercles. Swift also pointed out this striking likeness. J. Weill reported the finding of Aschoff's nodules in cases of acute tuberculous rheumatism. He expressed the belief that there was no histopathological distinction between these cases and those of acute rheumatic fever. In this connection should be remembered the similarity between tubercles and the focal collections of round cells described by Allison and Ghormley as being found in the synovial membrane in cases of chronic atrophic polyarthritis.

Recently, Bezançon, M.-P. Weil, Delarue, and Oumansky reported a case in which there was a history of familial tuberculosis and an old pulmonary lesion was present. This patient had attacks of subacute polyarthritis. Inoculation of joint fluid into guinea-pigs produced both typical tuberculous lesions and the "*forme ganglionnaire*", which will be described later. Inoculation into guinea-pigs of a blood culture from the patient produced the latter type of lesion. On microscopic examination of synovial tissue there were no definite tubercles, but perivascular collections of polymorphonuclears, lymphocytes, histiocytes, and plasma cells were found. Acid-fast bacilli were found in this synovial tissue. At necropsy, similar collections of cells were found in the lungs, liver, spleen, and heart muscle. These observers stated their belief that the lesions were similar to Aschoff's nodules and were allergic manifestations of tuberculosis.

De Chanaleilles expressed the belief, similar to that of Favre, that the old, specific pathological conception of tuberculosis had been too strongly

maintained. These observers feel that other tissue reactions may also be tuberculous, depending on the type of tissue affected and the form of the tuberculous inciting agent.

Experimental Evidence: Much experimental work has been done to sustain the diagnosis of tuberculous rheumatism. Dor, Lannelongue, Arloing, Thévenot, and Milian injected cultures of attenuated bacilli of tuberculosis intravenously into rabbits and produced swellings of several joints, as well as hydrops and granulations, without, however, typical microscopic evidence of tuberculosis. Poncet and Leriche, and Arloing noted that, in rabbits exposed to repeated injections of attenuated bacilli of tuberculosis, hydrarthrosis and granulations of joints developed with no trace of a specific tuberculous lesion. Broden, by similar methods, obtained lesions varying from simple inflammation to typical tuberculosis of joints. Landouzy, Gougerot, and Salen injected attenuated bacilli into the epiphyses of dogs. Mild, transient arthritis resulted. Later, a small amount was injected subcutaneously, with production of severe arthritis in the sensitized joints. Dominici and Ostrowsky claimed to have produced clinically suggestive polyarthritic lesions in animals by subcutaneous and intravenous injections of tuberculin. Vaudremer injected the filtrable virus of Koch's bacilli subcutaneously into guinea-pigs, producing generalized arthritis which he thought was tuberculous rheumatism.

Laboratory Evidence: The tuberculin test has been used by many observers in an attempt to establish the diagnosis of tuberculous rheumatism. De Chanaleilles stated that in children it was an undeniable aid in determining the nature of the polyarthritis. He said that in adults a negative reaction was good evidence that there was no tuberculous infection, and that the polyarthritis present was not tuberculous rheumatism. Milian, Oppenheim, and Lamy reported fifty-nine cases of chronic polyarthritis (atrophic) in which the subcutaneous tuberculin test was consistently positive. They did not state, however, in how many of these cases there was associated visceral tuberculosis. Kuss recommended uniform and minute doses in order to get a diagnostic reaction, and he considered a positive cutaneous test suggestive of the tuberculous etiology of polyarthritis. Mosny and Harvier reactivated rheumatic purpura by administration of tuberculin subcutaneously. By the intradermal method, Oppenheim and Lamy obtained ninety-nine per cent. positive tests in cases of chronic atrophic polyarthritis and seventy-seven per cent. in other cases.

With that type of cutireaction in which only an abrasion is made on the skin, Souques and Cawadias obtained consistently positive reactions in cases of chronic polyarthritis (unclassified). In acute cases, Grenet obtained fifty-seven per cent. and Jousset eighty-six per cent. positive reactions. Milian claimed that the cutireaction never occurs in non-tuberculous cases. De Chanaleilles and Bernard expressed the belief that the reaction was good evidence of latent tuberculous infection, but

they did not state that it was conclusive proof that a case of polyarthritis is of tuberculous nature. Willis, speaking of the tuberculin reaction in general, stated, "it is an infallible sign of tuberculous infection but it gives no reliable cue as to whether tuberculous infection is synonymous with tuberculous disease in the patient tested".

Bezançon and others have noted a marked focal reaction to tuberculin in joints which they consider to be the seat of tuberculous rheumatism and not in joints which are sites of "tumor albus". This focal reaction has been hailed as an excellent diagnostic sign by Weissenbach, Françon, Perlès, and Martineau; by Reitter, by Bezançon, Bernard, Oumansky, and Gaucher, and by de Chanaleilles. These observers noted that in cases which they thought were examples of tuberculous rheumatism intradermal or subcutaneous injections of tuberculin caused a flare-up of the inflammatory condition in the involved joints, with no reaction in the normal joints. De Chanaleilles claimed that the reaction would not be elective,—that is, it would not be limited to the diseased joints if it were merely due to any foreign protein.

Culture of Koch's bacilli from the joint fluid is held by Bezançon as positive proof of tuberculous rheumatism, but he has been able to obtain this proof very rarely. Reitter has obtained consistently positive results by cultures from the joint fluid in his cases of polyarthritis, especially of the acute type. He is quoted by J. Weill as having found Koch's bacilli in the joint fluid of each of a series of fifteen patients with acute polyarthritis. Paisseau and Oumansky, Bezançon, Bernard, and Célice also have obtained positive results. Positive cultures of bacilli of tuberculosis from regional lymph nodes in cases of polyarthritis (unclassified) have been made by Milian; from the tonsils, with no specific tuberculous pathological change, by Amersbach and Löwenstein; and from the synovial membrane by Bezançon, Weil, Delarue, and Oumansky.

Positive results in serodiagnosis by agglutination methods were reported by Arloing and Courmont in cases of polyarthritis of various types. Recently, the complement-fixation test has been used in an attempt to establish the diagnosis of tuberculous rheumatism. Mozer and Fried expressed the belief that this reaction was as valuable in the diagnosis of tuberculosis as the Wassermann test in syphilis. They did not state, however, that a positive test was conclusive proof of the tuberculous etiology of polyarthritis. Kahlmeter obtained positive results in sixty per cent. of twenty cases of atrophic polyarthritis. Woolley, referring to the complement-fixation test, stated that it gave positive results in sixty per cent. to eighty per cent. of cases, regardless of the situation of the tuberculous process, but depending on the stage of the disease, and that normal persons or persons with non-tuberculous conditions rarely gave positive results.

Dor, Dieulafoy and Griffon, Carnot and Terris, and Gougerot claimed to have noted the presence of bacilli of tuberculosis by direct smear from the synovial fluid in cases of polyarthritis. Bezançon has

found the organisms in a joint which grossly gave no evidence of inflammatory lesions.

Several observers, including Widal and Ravaut, have stated that the cellular constituents of the synovial fluid, especially the increase in lymphocytes, may be suggestive of tuberculous origin in a case of polyarthritis.

Melchior, in 1910, first reported the finding of Koch's bacilli in the blood stream of a patient who had what Melchior thought was tuberculous rheumatism. Recently, Löwenstein has devised a technique for culture of these organisms from the blood by means of which he has obtained consistently positive results in acute cases of polyarthritis. On analysis, these cases would be classified by physicians in this country as either acute rheumatic fever or acute infectious polyarthritis. Löwenstein expressed the belief that the majority of cases of acute polyarthritis of unknown origin were in reality tuberculous in nature. J. Weill has said that blood culture is one of the recent tests which has clinched the diagnosis of tuberculous rheumatism. Kurashiga and Rosemberg have obtained almost 100 per cent. positive results in acute cases of polyarthritis. Other observers have reported positive results in from six per cent. to ten per cent. of their cases, most often in the acute type. Nanu, Jonesco, and Stéphanesco, in a series of twenty-one cases of various forms of tuberculosis, obtained positive blood cultures in two cases; one patient had pleurisy and the other, polyarthritis. R. Mach and E. Mach were successful in obtaining positive blood cultures of bacilli of tuberculosis in two of five cases of acute polyarthritis.

More rapid sedimentation of erythrocytes, lower leukocyte count, and higher percentages of lymphocytes in the blood have been suggested as evidence of tuberculous rheumatism as distinguished from other forms of polyarthritis. These methods have received little recognition.

Positive results following inoculation of guinea-pigs with fluid from the joints of patients with polyarthritis have considerably advanced the concept of tuberculous rheumatism in the minds of many observers. Among the contemporaries of Poncet, positive results were obtained by Dor, Barbier, Milian, Dieulafoy and Griffon, and Patel. Mailland believed that negative results were of no importance because of the attenuation of the organism. More recently, numerous successes have been reported both in acute and in chronic cases. Carnot and Terris, Laederich, Mamou, Arager, and Léonard, and Harvier, Rachet, and Lemaire have reported positive findings in cases of recurrent polyarthritis. The last mentioned writers obtained a positive test with fluid from one joint and a negative test with fluid from another joint. Paisseau and Oumansky, Dufour and Écalle, and Bezançon, Bernard, Oumansky, and Gaucher have observed positive reactions in guinea-pigs in cases of polyarthritis associated with definite tuberculous lesions of the lungs or the joints.

In the case of Dufour and Écalle, three joints gave positive results. Reports by most authors give results from only one joint. Cooperman,

Ginnes, and Delbet have reported positive reactions in guinea-pigs in their cases of polyarthritis. Ory, in a series of 300 cases of polyarthritis, found seven in which reactions in guinea-pigs were positive. The majority of the cases included by these writers are probably of the atrophic type of polyarthritis, although, for the most part, no clear-cut distinction is made.

One of the most important recent advances which may lead to establishing the diagnosis of tuberculous rheumatism is the work of Calmette, of Valtes, and of Oumansky in demonstrating the "*forme ganglionnaire*" of tuberculosis in guinea-pigs. These observers have shown that attenuated organisms may produce, not the classical picture of tuberculosis in the guinea-pig, but merely regional enlargement of lymph nodes. Bacilli are not often seen in these nodes, but reinoculation of such macerated tissue into a second and possibly a third and a fourth guinea-pig will finally produce typical tuberculous lesions in the peritoneum, liver, and spleen, and will lead to the demonstration of Koch's bacilli. Oumansky, therefore, has expressed the belief that a specific filtrable virus may be responsible for such atypical lesions, with the production of specific tuberculous pathological change only on transformation of the virus into bacilli of tuberculosis. J. Weill has expressed the belief that this finding is a tremendous step in advance in the solution of the problem of tuberculous rheumatism.

De Chanaleilles stated that some observers advised measures to increase the activity of the bacillus or the virus in guinea-pigs by using acetone extracts of the organisms or by intraperitoneal injection of calcium phosphate. Bezançon, and Baron and Durand have reported positive results with guinea-pigs into which was injected the blood of patients with polyarthritis (unclassified). J. Weill has also had some success with this method in cases of acute tuberculous rheumatism.

Therapeutic Evidence: Many writers believe that patients with tuberculous rheumatism are more resistant to the action of salicylates than are those with acute rheumatic fever or even atrophic polyarthritis. Among those who have expressed this belief are Poncet and Leriche, Bezançon, Bernard, and Célice, Pic, Frugoni and Persico, Viton, and many others. Improvement in the condition of the joints by the use of tuberculin has been cited by Pic and Chapuy as evidence of tuberculous etiology in cases of chronic atrophic polyarthritis. In this connection, Ponndorf suggested the use of "cutivaccine"—that is, intracutaneous administration of tuberculin—in the treatment of cases of chronic polyarthritis. Paul combined this with a vaccine of pyogenic bacteria in the belief that a mixed infection was responsible for chronic polyarthritis. Viton stated that, when the condition was recognized early and treated with extremely minute doses of tuberculin, patients with tuberculous rheumatism might be spared serious trouble. Frugoni and Persico observed that tuberculous rheumatism was less tolerant to treatment by local application of heat than other forms of polyarthritis.

CONTRADICTORY FINDINGS

Since the introduction of the subject of tuberculous rheumatism by Poncet in 1897, there has been continual opposition to acceptance of this condition as a clinical entity. During the years of discussion and investigation, many observations have accumulated which seem to contradict the findings of the proponents of tuberculous polyarthritis.

Concerning the incidence of a family history of tuberculosis in cases of polyarthritis, Coste has expressed the belief that it is no higher than that which is encountered in other non-tuberculous diseases. He feels, however, that in acute cases of polyarthritis there is a distinct familial predisposition to inflammatory involvement of several joints. Betchov, on the other hand, noted a family history of polyarthritis in only five per cent. of patients with pulmonary tuberculosis who were under treatment in a sanatorium.

With reference to the question of associated visceral tuberculosis, Dumarest, Mollard, Sivrière, and Papatestas found among 1,000 tuberculous patients at the Sanitorium Mangini only fifty-six patients (5.6 per cent.) who had had symptoms of generalized arthritis. Lawrason Brown, in a series of 4,499 tuberculous patients at Saranac Lake, found only eleven (0.2 per cent.) who had had symptoms of polyarthritis. Pemberton and Peirce, in a large series of cases of arthritis of various types, noted that in only a few were there signs of active pulmonary tuberculosis. Hageneau and Bernard, in a series of thirty-one cases of chronic senescent polyarthritis (hypertrophic), found only one case in which there was any evidence of visceral tuberculosis. Raw stated he had not encountered a single instance of tuberculous rheumatism in 6,000 cases of pulmonary tuberculosis. Grocco and Achard felt that visceral tuberculous lesions often developed in cases of chronic polyarthritis just as they developed in persons weakened from any form of chronic disease. Stewart thought that tuberculous infection might, by lowering resistance, predispose to non-tuberculous forms of polyarthritis.

Most writers agree that tuberculous rheumatism, as described by its proponents, is clinically indistinguishable from other forms of polyarthritis. Poncet, Pic, Ory, J. Weill, and others have expressed the belief that cardiac complications in tuberculous rheumatism are common, especially in the acute form, so that this can hardly be accepted as a characteristic which will help to distinguish tuberculous rheumatism from acute rheumatic fever. In this connection, Gauthier, Coste, and Ory have warned against confusing tuberculous rheumatism with acute rheumatic fever, "*maladie de Bouillaud*", which it may simulate. Many writers, however, have apparently included cases of acute rheumatic fever in the group which they have called tuberculous rheumatism.

Ory has expressed the opinion of numerous observers that the later development of proved tuberculous arthritis in joints which are sites of atrophic polyarthritis is not indicative of tuberculous etiology of the

original polyarthritis, but, rather, that it suggests a superimposed tuberculous infection. Pellé has shown the danger of assuming that polyarthritis, associated with pulmonary tuberculosis, is in itself tuberculous. He has reported three such cases, none of which is considered by him to be an instance of tuberculous rheumatism because of negative findings from examination of the joint fluid (including inoculation of guinea-pigs) and the lack of resistance of these patients to administration of salicylates. Rist and Dufour still deny the existence of tuberculous rheumatism as a clinical entity, maintaining that the presence of polyarthritis in tuberculous patients is merely a coincidence, and that its tuberculous origin cannot be demonstrated.

Roentgenographically, Barjon could find nothing which would permit the diagnosis in cases in which tuberculous rheumatism was suspected. Most observers concur with this view. Paisseau and Oumansky stated that some joints in cases of tuberculous rheumatism had the roentgenographic characteristics of tuberculosis, while others resembled the joints in gout. Van Breemen noted smooth erosion at the bases of the phalanges, resembling the characteristics found in roentgenograms of gout. Mollard and Charleux have expressed their disbelief that there are any typical roentgenographic signs of tuberculous rheumatism.

In examination of joints thought to be the seat of tuberculous rheumatism, Arloing and Lommel found ordinary granulation tissue and hydrops, but no specific lesions. Mailland reported the finding of simple inflammatory tissue. Many other negative observations of this kind have led observers to feel that these cases of polyarthritis are not tuberculous in the accepted sense of the word.

Experimentally, Ory and Van Beneden have been unsuccessful in producing lesions of tuberculous rheumatism in rabbits and guinea-pigs by means of subcutaneous and intravenous injection of attenuated bacilli. Virulent organisms, however, produced generalized infections and occasionally typical "white swellings". Ory admitted that the experimental proof of tuberculous rheumatism was difficult to obtain. Fraser stressed the difficulty of reproducing experimentally any type of tuberculous lesions of joints.

Most laboratory tests are considered by the majority of observers to give inadequate proof of the tuberculous etiology of polyarthritis. Bezançon expressed the opinion that a positive tuberculin reaction was a good sign that the patient had an active or inactive tuberculous infection somewhere in the body, but that it was no proof of the tuberculous origin of the polyarthritis. Sicard and Descomps, and Souques and Cawadias reported a very small percentage of positive results from tuberculin tests in their cases of chronic atrophic polyarthritis. Concerning the cutireaction, Magni and Vigneron stated that in acute tuberculous rheumatism there was suppression of this skin reaction during the period of the acute symptoms, so that this was no means of distinguishing the condition from other forms of acute polyarthritis.

De Chanaleilles stated that the lesions of tuberculous rheumatism might be lighted up by subcutaneous or intravenous injection of any non-specific foreign protein, but felt that the normal joints were also affected by this method; whereas, with the use of tuberculin, the normal joints would give no evidence of change. Cooperman stated that focal reactions following intracutaneous injections of tuberculin were non-specific because typhoid vaccine would produce the same results. Labbé obtained positive focal reactions by the use of non-specific serum in twenty per cent. of his cases of polyarthritis (unclassified) with associated visceral tuberculosis.

The majority of investigators have been unable to obtain Koch's bacilli from culture of joint fluid in cases of polyarthritis. Ory expressed the belief that, even if results were positive, the organisms might be only concomitant invaders, not responsible for the changes in the joints.

Bezançon expressed the belief that the complement-fixation test gave evidence merely of the presence of a tuberculous focus in the body and was not indicative of the tuberculous origin of polyarthritis. De Chanaleilles felt that this test was of little value in diagnosis. Bezançon and Vigneron have encountered negative results from complement-fixation tests in their cases of polyarthritis (unclassified).

Most observers have been unable to confirm the finding of Koch's bacilli in the blood stream in various forms of polyarthritis. Lange and Lindemann, Berry, Bagmeister and Reuter, Saenz, Ory, Corelli, Spier, Bingold, Pollack, Favero, Opitz, and Wilson have been unsuccessful in this attempt. Kahlmeter reported independent study of the blood culture in forty cases made by himself and by the laboratory of Löwenstein. The latter found positive cultures of Koch's bacilli in ten per cent. of the cases of polyarthritis and in eleven per cent. of the cases of erythema nodosum. Kahlmeter obtained consistently negative results. Coste expressed the belief that it was possible for acute polyarthritis of any type to cause migration of Koch's bacilli from a latent focus into the blood stream, so that positive blood cultures might be only coincidental findings.

Troisier and Monaldi obtained positive blood cultures of Koch's bacilli in cases of pneumonia, streptococcic septicaemia, and meningitis. Löwenstein has isolated the organisms from the blood of patients with nervous disorders. Frugoni and Persico stated that in tuberculous rheumatism the positive reports, even if confirmed, would be unimportant because Koch's bacilli had been cultured from the blood in cases of retrobulbar neuritis, arteriosclerosis, apoplexy, and schizophrenia, with no clinical or post-mortem evidence of tuberculosis.

It is the feeling of most writers that when they obtain a positive guinea-pig test by the use of joint fluid they are dealing with a true tuberculous joint (tuberculous arthritis, not tuberculous rheumatism) caused by the presence of viable bacilli of tuberculosis. In the case of the "*forme ganglionnaire*" the possibility of contamination and the lack of corroborative evidence has caused hesitancy in the acceptance of this procedure.

Paisseau and Oumansky, and Bernard have had good results in the treatment of tuberculous rheumatism with salicylates. They do not consider this a diagnostic criterion. Duvernay noted that cases of chronic atrophic polyarthritis reacted to various non-specific excitants. He concluded that the vaccines of Ponndorf and Paul had only the effects of a simple foreign protein.

COMMENT

The case which has been built up in favor of the acceptance of tuberculous rheumatism as a clinical entity by the various observers quoted in this outline has some features worthy of consideration. Modern writers on the subject, for the most part, are no longer trying to prove that hypertrophic (senescent) arthritis is a form of tuberculous rheumatism. Although Poncet considered hypertrophic tuberculous rheumatism in his description of the disease, this idea has fallen into disrepute. The problem now consists of distinguishing between either acute rheumatic fever or chronic atrophic (infectious) arthritis on the one hand and the acute, subacute, and chronic forms of so called tuberculous rheumatism on the other. The basic argument in favor of tuberculous polyarthritis is that, in the absence of any other constantly demonstrable infectious agent, it is difficult to rule out the possibility of tuberculosis as the etiological factor in a case of polyarthritis when a definite visceral tuberculous lesion, whether it be active or quiescent, coexists. Moreover, when a typical tuberculous "tumor albus", the specificity of which can be pathologically proved, is superimposed on a joint which was formerly the seat of what was apparently chronic infectious atrophic arthritis of unknown etiology, there immediately arises the possibility that the original polyarthritic infection was also tuberculous. Altered resistance in the single joint, possibly due to trauma, may have been responsible for the advanced pathological change in that region. Finally, when polyarthritis of the atrophic type develops subsequent to a definitely proved tuberculous tumor albus, the possibility of polyarticular involvement by an attenuated form of tuberculous infecting agent can hardly be entirely excluded.

While the possibility of tuberculous polyarthritis must be considered by inference, its diagnosis cannot be established without definite proof, and the accepted evidence in confirmation of tuberculous infection lies along two lines,—namely, pathological and bacteriological. While it is apparent from the foregoing outline that these specific proofs of tuberculous infection are rare in cases of tuberculous rheumatism, and that when they do occur they are considered by some observers as evidence of a superimposed tuberculous infection, their occasional disclosure is sufficient to be of interest. The finding of Koch's bacilli in the joint fluid or synovial membrane, the occasional demonstration of typical tuberculous pathological change in a joint, the isolation of Koch's bacilli from the blood stream, the finding of acid-fast bacilli in guinea-pigs after inoculation of joint fluid, and, lastly, the discovery of the "*forme ganglionnaire*"

in guinea-pigs which otherwise show no signs of tuberculous infection, all are forms of evidence which cannot be abruptly discarded. Furthermore, the final word in the description of the microscopic changes in tissue in tuberculosis has not as yet been written. Pathological changes in the eye, the peritoneum, and the blood vessels, generally attributed to tuberculosis, differ entirely from the typical tuberculous changes in tissue seen, for example, in the lungs and in the joints. In this connection, the microscopic resemblance of Aschoff's nodules, seen in rheumatic fever, and of the focal collections of round cells, noted in chronic atrophic arthritis, to typical tubercles cannot be overlooked. It is not unreasonable to believe that a tuberculous infecting agent of a somewhat different type, or of altered virulence, might produce in joints or in the lungs microscopic changes which do not possess the characteristic cellular elements and configuration universally attributed to tuberculosis. Under these circumstances, the fact that typical tuberculous microscopic pathological change is rarely found in these cases of tuberculous rheumatism cannot be considered as evidence entirely contradictory to a tuberculous etiology.

There are many strong arguments against acceptance of the entity of tuberculous rheumatism. Although the older percentages of the incidence of familial tuberculosis and tuberculosis elsewhere in the body in cases of polyarthritis are for the most part extremely high, it must be remembered that there was more tuberculosis among the general population formerly than exists today. Furthermore, even the older observers varied in their impressions as to the relationship of tuberculosis and polyarthritis, so far as these factors are concerned. In addition, their cases are poorly classified, and statistics are given in series of cases which include various forms of arthritis under the term "rheumatism". It is utterly useless to attempt to establish the tuberculous etiology of polyarthritis because of an associated visceral tuberculous lesion. The law of coincidence, cited by many proponents of tuberculous rheumatism as confirmatory evidence, works both ways. It is just as conclusive an argument that the two conditions are entirely independent.

The similarity between the tuberculous and the arthritic habitus has long been observed, but this alone can hardly be interpreted as an argument for common etiology. Both are slowly progressive chronic diseases which chiefly attack persons of the same class and walk of life. The general constitutional effects are similar.

Clinically, there is no certain means of distinguishing tuberculous rheumatism in one case from chronic atrophic polyarthritis, and in another from acute rheumatic fever. Various observers have recorded their ideas as to diagnosis by symptomatology, physical findings, or therapeutic effects, but there has been no unanimity of opinion and no clear-cut method of distinction. There is no characteristic roentgenographic evidence of tuberculous rheumatism, just as there are no typical physical signs. Some cases suggest chronic atrophic arthritis; whereas others resemble the picture of gout. After a review of the literature, the im-

partial observer can find no definite clinical picture of the syndrome of tuberculous rheumatism.

The experimental and laboratory evidence falls short of clinching the diagnosis. Experimentally, the lesions in the joints produced by tuberculin and similar preparations are merely those which might result from injection of any foreign protein. The tuberculin test may be of service in ruling out the possibility of tuberculous infection in the body, but, when positive, it does not signify that a case of polyarthritis is tuberculous in origin. Agglutination, sedimentation of erythrocytes, and similar laboratory tests have not been accepted as positive evidence even by the most enthusiastic proponents of the syndrome of tuberculous rheumatism. Positive results of inoculation of guinea-pigs with material from a single joint are evidence merely that bacilli of tuberculosis are present in that joint, not that the polyarthritis is tuberculous. The reports of positive cultures for Koch's bacilli from blood and joints, and the demonstration of the "*forme ganglionnaire*" in the guinea-pig are all open to question because of the mass of contradictory and insufficient corroborative evidence. Even if they are proved to be correct, the evidence must be found in more than a single joint in order to be at all persuasive.

Pathologically, there has been no consistent demonstration of what are considered the characteristic microscopic changes in tissue, due to tuberculosis, in joints that are the seats of tuberculous rheumatism. The finding of such changes is the exception rather than the rule and immediately suggests a tuberculous infection superimposed on ordinary chronic atrophic polyarthritis or acute rheumatic fever. Until our conception of the microscopic pathological changes in tuberculosis is altered by some future revelation, this will remain the outstanding pitfall in the establishing of the diagnosis of tuberculous rheumatism. It is perfectly possible for a typical tuberculous joint to be present before, after, or coincident with, acute rheumatic fever or chronic atrophic polyarthritis. Such a situation is not a tenable argument for an etiological relationship.

Briefly, in many cases simulating acute rheumatic fever and chronic atrophic polyarthritis, there have been findings suggestive of tuberculosis as the causative agent, but in no case has irrefutable evidence been furnished to establish the diagnosis of tuberculous rheumatism. Further detailed study of the clinical, bacteriological, experimental, and pathological aspects of these cases, with such a possibility in mind, and utilization of the newer methods which have been outlined in this paper might possibly lead, however, to an altered conception of the genesis of tuberculous infection and to a solution of the problem of tuberculous rheumatism.

STATISTICAL STUDY

In view of the divergent reports in the literature concerning the relation of polyarthritis to tuberculous disease elsewhere in the body and to familial tuberculosis, an investigation was made of cases seen at The Mayo Clinic between the years of 1923 and 1932, inclusive. Two hundred

and fifty cases of chronic infectious (atrophic) polyarthritis, 150 cases of acute rheumatic fever, and 250 control cases were studied with no attempt at selection except that, in the cases of arthritis, only those were included in which there was involvement of at least four joints. The controls consisted of consecutive cases other than cases of arthritis, chosen at random in the same period. These patients complained of a great multiplicity of troubles in no way related to the joints.

Of the 250 patients with chronic infectious (atrophic, rheumatoid) arthritis, thirty-eight (15.2 per cent.) gave histories of familial tuberculosis. Eight (3.2 per cent.) had definite tuberculous lesions elsewhere than in the joints. Five of these had quiescent thoracic lesions; two had lesions of active pulmonary tuberculosis; and one had a tuberculous cutaneous infection. In other words, only three of 250 patients had any active tuberculosis. Of the equal number of control cases, in twenty-nine (11.6 per cent.) there was evidence of tuberculosis in the family, and in twenty (8 per cent.) there was tuberculosis elsewhere in the body. Of the latter group, eighteen presented signs of quiescent pulmonary tuberculosis; one had involvement of a costochondral junction; and one had active pulmonary tuberculosis. Of the 150 cases of rheumatic fever, in sixteen (10.6 per cent.) there were family histories of tuberculosis; and in two (1.3 per cent.) evidence of tuberculosis was found in the form of quiescent thoracic lesions. It is apparent that there is no significantly higher incidence of tuberculous family history or associated tuberculosis in these cases of polyarthritis than in the group of controls. The results of the investigation of the three groups are presented in Table I.

TABLE I

STUDY OF CASES SEEN AT THE MAYO CLINIC, 1923 TO 1932 INCLUSIVE

	Chronic Infectious Arthritis	Controls	Acute Rheumatic Fever
Total cases	250	250	150
Familial tuberculosis	38 (15.2 per cent.)	29 (11.6 per cent.)	16 (10.6 per cent.)
Tuberculosis elsewhere in the body	8 (3.2 per cent.)	20 (8.0 per cent.)	2 (1.3 per cent.)
Active pulmonary tuberculosis	2	1	0

PATHOLOGICAL STUDY

A further investigation was made of the cases of what was considered before operation to be typical chronic (non-tuberculous) atrophic polyarthritis involving four or more joints, the diagnosis of which had been checked by microscopic examination of tissue or by the routine inocula-

tion of guinea-pigs. During a similar period of years, seventy-five cases of this type had been so examined. In sixty-four cases, biopsy, arthrodesis, synovectomy, or some other operative procedure permitted microscopic examination of tissue. In eleven, aspiration and inoculations of guinea-pigs were performed. Of this entire group, in seven cases the diagnosis was changed to tuberculous arthritis at the time of operation as a result of examination of tissue; and in another case inoculation of guinea-pigs resulted in tuberculosis. In ten cases, in which tissue was not removed from joints, but joint fluid was injected into guinea-pigs, no tuberculous lesions were found. In fifty-seven of the cases, following operation, purely inflammatory tissue was found by the pathologist. In several, including cases of tuberculous etiology and cases of non-tuberculous etiology, inoculations of guinea-pigs were made in addition to examinations of tissue. In no case was there any discrepancy between the two reports.

In forty-nine of the sixty-four cases in which the diagnosis of either tuberculosis or inflammation had been made by examination of tissue, the preserved specimens were reexamined microscopically. In seven cases, the diagnosis of tuberculosis made at the time of operation was corroborated. In forty-two, non-specific inflammatory granulation tissue was found. Of the latter group of specimens, three presented focal perivascular collections of round cells. In ten there was evidence of necrosis of tissue, and in ten the intimal layers of the blood vessels were definitely thickened. Giant cells of the foreign-body type were noted in three cases. In no case was there any microscopic pathological change which might be construed as representing a transition stage between ordinary inflammatory tissue and tuberculosis.

In summary, therefore, the pathological study disclosed that in eight of a series of seventy-five cases, in which a diagnosis of chronic atrophic polyarthritis had been made prior to operation, specific evidence of tuberculous involvement was later disclosed. In each case the results were obtained by examination of a single joint. In the remaining cases, microscopic examination of the synovial membrane revealed simple inflammatory tissue with occasional necrosis of tissue, intimal thickening, perivascular collections of round cells, and foreign-body giant cells. No lesions suggestive of Aschoff's nodules (rheumatic fever) or of the tubercle-like clusters of Allison and Ghormley (chronic atrophic arthritis) were observed.

TUBERCULOUS CASES

In five of the eight tuberculous cases there were histories of primary, generalized arthritis, with subsequent complete or incomplete remission and localization of pain and swelling in one of the involved joints. This prolonged disease of the single joint was the indication for biopsy or inoculation of guinea-pigs for diagnosis, and these examinations disclosed typical tuberculosis. Little was found in the other joints at the time of

examination, and microscopic examination or inoculation of guinea-pigs was not attempted. In the other three cases there were histories of pain and swelling of a single joint, followed by transitory recurrent attacks of polyarthritis. Here again, only the tissue from the single involved joint was examined and was found to be tuberculous. In each of the eight cases, the diagnosis of tuberculous arthritis of the single joint was suspected before operation, but the associated generalized atrophic arthritis introduced a confusing factor. There was a familial history of tuberculosis in one of the eight cases. In one case there was evidence of active pulmonary tuberculosis, and in another a quiescent thoracic lesion was disclosed. In three cases, possible foci of infection in the teeth and tonsils were demonstrated. In the remainder, search for foci was not made.

It would seem plausible to explain the association of tuberculosis and polyarthritis in these eight cases in one of two ways. Tuberculous infection may have developed in a joint, the resistance of which was lowered by previous attacks of non-tuberculous polyarthritis, or generalized atrophic arthritis may have developed subsequent to, but independent of, definite tuberculosis. Nevertheless, in view of the work which has been summarized in this paper, it is probable that some would consider the two conditions to be of similar etiology. Despite the tremendous amount of work which has been done on the subject of arthritis, experienced observers still disagree as to the specific causative agents of the infectious type. In this situation there seems to be no good reason to disregard entirely the possibility of atypical tuberculous infection.

SUMMARY

A résumé of the literature on the subject of tuberculous rheumatism has been presented. As described by its proponents, this condition is a form of polyarthritis, simulating in some cases acute rheumatic fever or in other cases chronic atrophic arthritis, but bearing some suggestion of tuberculous etiology. Familial tuberculosis, associated visceral tuberculosis, demonstration of Koch's bacilli in the synovial fluid and in the blood stream, positive results of inoculations of guinea-pigs with joint fluid, and in some cases the presence of a typical tuberculous joint before, coincident with, or subsequent to the development of polyarthritis have been considered as evidence for the diagnosis of tuberculous rheumatism. The condition is thought to be due to a tuberculous toxin from some distant focus, a filtrable virus, an attenuated form of bacilli of tuberculosis, or an allergic reaction. Formation of true tubercles, therefore, is not the expected finding and, when such pathological change is present, a superimposed tuberculous arthritis, rather than the condition of tuberculous rheumatism, is thought to exist. Focal collections of round cells, plasma cells, and histiocytes, somewhat resembling tubercles and Aschoff's nodules, isolated instances of necrosis, intimal thickening and vacuolization of the vessels, and the presence of giant cells and endothelial cells have been reported in studies of the synovial membrane in cases of tuberculous rheumatism. These have been interpreted as representing either a transition

stage between simple inflammatory tissue and tuberculosis or an allergic manifestation of the latter. If typical tuberculous arthritis develops in a joint which was previously the site of atrophic polyarthritis, the finding of characteristic pathological change may be due to transformation within the joint of the virus form of infecting agent into virulent bacilli of tuberculosis. This virus form is thought to be the explanation of the *"forme ganglionnaire"* of tuberculosis of guinea-pigs, in which inoculation of fluid from a patient with atrophic polyarthritis may produce only enlargement of regional lymph nodes. Subsequent injection of this macerated lymphoid tissue into a second or third guinea-pig may lead to the production of typical tuberculosis in the guinea-pigs and the demonstration of Koch's bacilli in the viscera of these animals.

Against acceptance of the syndrome of tuberculous rheumatism have been arrayed a large number of competent investigators who have argued that there is no adequate clinical method of identifying it, no consistently characteristic roentgenographic evidence, no experimental or laboratory evidence in its favor that is not highly controversial, and no consistent demonstration of any characteristic microscopic pathology.

A statistical study of a series of 150 cases of acute rheumatic fever and 250 cases of chronic atrophic polyarthritis has revealed no significantly higher incidence of familial tuberculosis or associated visceral tuberculosis than that found in a group of 250 control cases. Of a series of seventy-five cases in which a diagnosis of chronic atrophic polyarthritis had been made, and in which the pathological characteristics of a single joint were determined by microscopic examination of tissue or inoculation of guinea-pigs, eight patients were found to be definitely tuberculous. The remainder gave no clear-cut evidence of an intermediary stage between simple inflammation and tuberculosis. In each of the eight cases, the tuberculous identity of the joint was suspected prior to examination of tissue or inoculation of guinea-pigs, but the association with multiple arthritis was confusing. Further investigation of cases of acute rheumatic fever and chronic atrophic polyarthritis, with the possibility of a tuberculous etiology in mind, will be required in order to determine the acceptance or rejection of the syndrome of tuberculous rheumatism. At present we would conclude that no incontrovertible proof exists to support the existence of such an entity.

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Note: A list of supplementary references will appear in the reprints.

POSTERIOR LUXATIONS OF THE LUMBOSACRAL JOINT

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It is of interest to note that, while spontaneous spondylolisthesis has been known for nearly a century [1], the reverse subluxation of the fifth lumbar vertebra backward on the top of the sacrum has not yet been clearly described. In reviewing the literature on the lumbosacral region, one gets a hint or two that such a condition might exist [2], and the reproduction of one roentgenogram in a recent article by Williams and Yglesias [3] actually shows the displacement, though only casual mention is made of it. However, the advance in x-ray technique has enabled us to get a much clearer view of this region from the lateral aspect and these posterior luxations are now attracting attention. In fact, a coincident but independent observation of this condition has been made by Dr. Alan Smith at the New York Orthopaedic Hospital. We have had the opportunity of comparing our findings on several occasions and our conclusions as to its frequency and etiology are essentially similar, though the manner of treatment and ultimate prognosis has not entirely coincided. The displacement is not as gross as that seen in the usual case of spondylolisthesis and it is rarely possible to detect the exact nature of the condition without accurately focused roentgenograms.

A verbal description of the condition is not to be compared with the visual demonstration given in the following roentgenograms, and will, therefore, for brevity's sake, be very limited.

The subluxation consists of a slight slipping of the body of the fifth lumbar backward, so that the posterior border of the body can be seen to overhang the top of the first sacral body by about one-half centimeter in an accurately focused lateral roentgenogram. The articular facets of the fifth lumbar vertebra seem to be displaced downward and posteriorly, which would decrease the fifth lumbar intervertebral foramen and this would seem to be one of the factors in the production of symptoms. The intervertebral disc may or may not be flattened or irregular, and the question as to the integrity of the nucleus pulposus cannot, in my opinion, be absolutely determined in all cases by x-ray, but seems to be inconstant. The lumbosacral angle is also inconstant, being variably increased, normal, or decreased. The presence of appreciable congenital malformation of the bones is often noted, but is not an essential concomitant. Analysis of the roentgenographic findings in each case is made in Column VII of the table of case analyses.

The first case in which we recognized the condition was seen in December 1932. The roentgenograms are shown as Figures 1 and 2. Three more cases followed in a short time, and finally, two months later, a member of my family showed a very clear-cut picture of the subluxation coming on symptomatically while stooping over to unfasten the hood of an

TABLE I

ANALYSIS OF CASES

Case and Age	Duration	Onset	Course	Location of Pain	Physical Findings	X-Ray Findings	Treatment	Result	Analysis
1. W. H. R. Male, 40 years. Dec. 1932.	4½ years.	Sudden. Lifting machinery.	Intermittent recurrences.	(a) Right lower back. (b) Both hips.	Muscle spasm ++. Slight curvature. Kernig +. Fair mobility.	0.7 cm. posterior displacement. Disc not reduced in size. Lumbosacral angle 135 degrees. No congenital anomalies. (Figs. 1 and 2.)	Support. Operation advised.	Support has been satisfactory.	Long-standing case with considerable luxation. Relieved by support sufficiently to refuse operation. No structural anomaly to account for onset without severe trauma—ordinary strain.
2. W. C. Male, 32 years. Dec. 1932.	2 weeks.	Sudden. Setting-up exercises.	Continuous, two weeks. Mild.	Mid-line, lower back. No radiation.	Free mobility. No deformity. Tender at lumbosacral junction. Kernig 0.	0.5 cm. posterior displacement. Disc not reduced in size. Lumbosacral angle 130 degrees. Sacralization of 5th lumbar? Spina bifida, 1st sacral. (Fig. 6.)	Support.	Relief with support. Worn occasionally now.	Structural anomaly. Mild strain but definite displacement. Quick relief with support.
3. Mrs. H. T. Female, 49 years. Dec. 1932.	1 year.	Nothing definite.	Five attacks of sudden pain. Duration 2 to 3 days.	Mid-line, lower back. No radiation.	Mobility fair. Muscle spasm ++. No deviation.	0.3 cm. displacement. Disc somewhat reduced. No anomalies. Lumbosacral angle 140 degrees.	Support.	Relief with support.	No structural anomaly. No precipitating cause. Relief with support.
4. R. W. Male, 40 years. Jan. 1933.	6 weeks	While intoxicated?	Constant dull pain with acute seizures of great severity.	No back pain. Right leg, sciatic distribution.	Muscle spasm +++. Flexion painful, otherwise free. Kernig +++. Sitting O. K. Standing and lying down painful.	0.6 cm. displacement. Disc flattened posteriorly. Spina bifida, 1st sacral. Lumbosacral angle 110 degrees.	Support. Manipulation and support. Operation advised.	Support and manipulation failed. Operation advised and refused. Still having pain.	Structural anomaly. Probable trauma. Failure of conservative and manipulative treatment. Should have fusion.
5. J. T. H. Male, 32 years. Jan. 1933.	1 day.	Stooping with legs straight.	Manipulation failed to relieve.	Mid-line back. Down both legs. Sciatic distribution.	Muscle spasm ++. Slight deviation. Kernig+++. Sitting O. K.	0.6 cm. displacement. Disc irregular. No congenital anomaly. Lumbosacral angle 128 degrees. (Figs. 3 and 4.)	Support after failure of manipulation.	Spontaneous relief in three weeks. Occasional recurrence.	Mild strain. Manipulation failed. Support relieved but occasional moderate recurrence points to possible fusion operation.
6. A. W. H. Male, 25 years. Feb. 1933.	5 months.	Partially buried and injured.	Other injuries. Fracture of 12th thoracic. Required cast and recumbency.	Mid-line, lower back. Both legs to knee.	Congenital short leg. Muscle spasm +. Kernig 0. Fracture of articular processes of 12th thoracic vertebra.	0.3 cm. displacement. Disc flattened posteriorly. No congenital anomaly. Lumbosacral angle 115 degrees.	Support.	Good recovery. Some disability. Compensation.	Severe trauma. Early adequate rest and support. Recovery with as little disability as one can expect in a compensation case.

TABLE I (*Continued*)

Case and Age	Duration	Onset	Course	Location of Pain	Physical Findings	X-Ray Findings	Treatment	Result	Analysis
7. M. S. Male, 38 years. Feb. 1933.	4 years.	Sudden. No precipitating cause.	Two very severe recurrences.	Knife-like. Mid-line, lower back. Radiates to both shoulders.	Deviation to left. Muscle spasm+. Mobility fair. Kernig+.	0.4 cm. displacement. Disc flattened throughout. Spina bifida, top of sacrum. Lumbosacral angle 122 degrees. (Fig. 7.)	Support. Operation advised.	Relief with brace. Operation suggested—not required.	Long duration. No apparent cause. Disc flattened without history of trauma. Sharp lumbosacral angle. Relief with support.
8. S. B. Male, 46 years. Feb. 1933.	1 day. Previous history of indefinite backache.	Auto accident.	———	Mid-line, lower back. Right leg.	Deep-set fifth lumbar. Muscle spasm++. Tenderness diffuse.	0.5 cm. displacement. Disc not changed. Marked arthritis. Lumbosacral angle 124 degrees.	Support.	Relief. Occasional mild recurrence of symptoms.	Immediate trauma. Arthritis. Relief with rest and support. Sharp lumbosacral angle.
9. G. M. Female, 20 years. Mch. 1933.	6 weeks.	Gradual. No trauma.	Increasing pain down right leg. Severe, two weeks.	Mid-line, lower back. Right leg.	Mobility restricted. Muscle spasm+++. Flexion painful. Spine hyperextended.	0.3 cm. displacement. Disc flattened. No anomalies. Lumbosacral angle 132 degrees.	Support.	Relief. ? recurrences as patient returned to "old country".	Young girl. No cause. Disc flattened. Support gave relief. No real end result.
10. Mrs. B. F. S. Female, 24 years. Mch. 1933.	2¼ years.	Catch on stooping.	———	Mid-line and right sacro-iliac. Right leg.	Flat back. Hyperextension painful. Tender across lower back.	0.6 cm. displacement. Marked congenital anomalies of pedicle and articulation, 1st sacral. Osteosclerosis. Disc flattened. Lumbosacral angle 135 degrees. (Figs. 9 and 10.)	Support.	Relief.	No trauma. Young woman. Congenital anomalies. Flattened disc. Relief by support.
11. G. S. Male, 22 years. April 1933.	6 weeks.	After playing basketball.	Stiffness. Difficulty in straightening up.	Low mid-line. No radiation to legs.	Tender right of midline. Lateral deviation to right. Muscle spasm++. No hyperextension possible. Catch on straightening.	0.4 cm. displacement. No anomalies. Disc normal. Lumbosacral angle 120 degrees. (Fig. 5.)	Support. Failure. Manipulation—failure. Fusion—success.	Fusion has been successful.	Only case requiring operation in this series to date. (Two others advised but refused.)
12. C. P. Female, 15 years. May 1933.	14 months.	Catch in back while horseback riding.	Ache after exercise.	Mid-line, lower back. No radiation to legs.	Hollow back. Tenderness. No spasm. Free mobility.	0.5 cm. displacement. Disc slightly flattened. Lumbosacral angle 135 degrees. (Fig. 8.)	Support.	Relief. Active.	No trauma. No anomaly. Cause of displacement obscure in so young a patient.

FIG. 1

Case 1. W. H. R. Fifth lumbar vertebra displaced 0.7 centimeter posteriorly. Disc not reduced in size. Lumbosacral angle 135 degrees. No congenital anomalies.

FIG. 2

Case 1. W. H. R. Anteroposterior view. Lumbosacral and sacro-iliac areas apparently normal.

FIG. 3

Case 5. J. T. H. Posterior displacement of 0.6 centimeter. Disc irregular. No congenital anomaly. Lumbosacral angle 128 degrees.

FIG. 4

Case 5. J. T. H. Negative except for some possible asymmetry of articular facets.

FIG. 5

Case 11. G. S. Displacement of 0.4 centimeter. No apparent anomalies. Disc normal. Lumbosacral angle 120 degrees. At fusion operation separation of the pedicles of the fifth lumbar vertebra was found.

FIG. 6

Case 2. W. C. Displacement of 0.5 centimeter. Disc not reduced in size. Lumbosacral angle 130 degrees. Sacralization (?) of fifth lumbar vertebra in anteroposterior view.

FIG. 7

Case 7. M. S. Displacement of 0.4 centimeter. Disc flattened throughout. Lumbosacral angle 122 degrees. Anteroposterior view showed spina bifida at top of sacrum.

FIG. 8

Case 12. Miss C. P. Displacement of 0.5 centimeter. Disc slightly flattened. Lumbosacral angle 135 degrees.

FIG. 10

Case 10. Mrs. B. F. S. Displacement of 0.6 centimeter. Disc flattened. Lumbosacral angle 132 degrees.

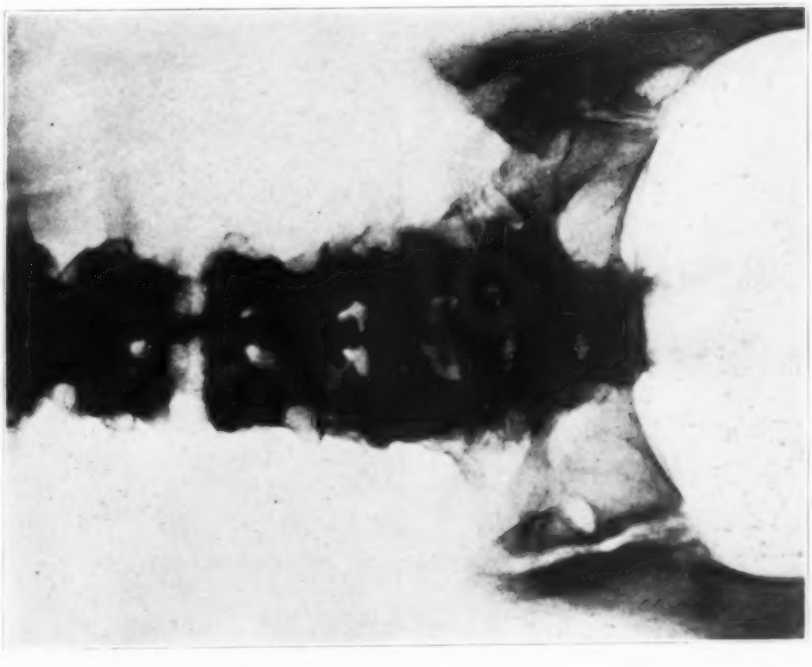

FIG. 9

Case 10. Mrs. B. F. S. Marked congenital anomalies of pedicles and articulations of first sacral vertebra. Osteosclerosis.

automobile (Figs. 3 and 4). The great variation in the cases as to history and findings, as well as treatment and course, is best illustrated by the preceding table of cases observed in the six months' period from December 1932 to May 1933. They were first presented informally to an interurban

FIG. 11

FIG. 12

FIG. 13

FIG. 14

Views of articulated skeleton from various angles and positions to show that variation in technique of roentgenography does not produce the posterior subluxation as an artefact.

surgical group, The Halsted Club, in May 1933, and have been followed for at least one year.

Later cases have confirmed the belief that we have here a genuine type of subluxation and not an artefact of roentgenography. As clinical pathological specimens are non-existent, and the presence of such a condition in the average cadaver must be very rare and also open to criticism of having been produced postmortem, only one real laboratory check upon the clinical roentgenograms was possible,—namely, an attempt to produce the same picture by x-raying an articulated skeleton from a wide variety of positions. All our attempts to reproduce a similar picture in this way failed, as is shown by four of the many views, which were taken from different angles as the changes in the iliac shadows indicate (Figs. 11, 12, 13, and 14).

A longer check-up of the course of these cases and additional information supplied by new cases now being discovered, both in private practice and in the hospital clinics, should throw much more light on the prognosis and treatment as well as on the etiology. It is interesting that in our office practice in the six months' period in which these twelve cases were seen, there were a total of one hundred and twenty-six cases in which roentgenograms of the lumbosacral junction were taken specifically for that joint. Therefore, ruling out roentgenograms showing this joint but taken primarily for injuries or lesions elsewhere, the apparent incidence of these subluxations is about ten per cent. of all cases where the lumbosacral joint is suspected. So it would seem that, while the posterior subluxation is less dramatic in appearance than spondylolisthesis, it is apparently far more common and must play a fairly important rôle in that heterogeneous mob called "low-back strains".

For the present at least, I feel that conservatism in the treatment of these cases is not amiss. Operative fusion has been required in some, and doubtless will increase in favor. However, the condition is certainly one which is purely mechanical, and in which delay for a trial of conservative measures does not entail any risk. Therefore, it seems prudent to counsel conservative measures and not advocate radical treatment by every surgeon on every case until our foundation of accurate knowledge concerning this condition is better laid. The rôle played by relaxation of the intervertebral disc or rupture of the nucleus pulposus must be carefully considered, as must congenital malformations in the neighborhood.

A large number of such cases must be accumulated and studied, preferably at a number of different clinics, so that independent analyses can be made from varied points of view. It seems to be extremely hard to secure dispassionate judgment on low back conditions as each observer seems to have a favorite lesion or a preferred method of attack. Therefore, it seems best that these cases be presented as clinical observations, and that this paper be considered as a presentation of a new phase of the old low-back-pain problem, to be further studied, rather than an attempt to advance an incomplete solution of it.

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POSTERIOR DISPLACEMENT OF THE FIFTH LUMBAR VERTEBRA *

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In proportion to its frequent occurrence and its importance as a cause of low back pain, posterior displacement of the fifth lumbar vertebra on the sacrum has received surprisingly little attention. The results of operation in six cases were given in a paper by Hibbs and Swift [1] in 1929, and it was briefly described by the writer [2] in the same year as one of the important causes of low back pain. Williams and Yglesias [3] in 1933 mentioned that it frequently is present in certain cases with abnormal facets in the lumbosacral joints. Except for these references the condition is ignored in the voluminous literature on abnormalities in the lumbosacral region. Indeed in some instances its existence is denied and there appears to be a rather wide-spread belief that posterior displacement does not and cannot occur. It is difficult to account for such statements, which can be based only on faulty or inadequate roentgenographic examinations, or on the failure to detect the displacement when the evidence is present. It was pointed out by Ferguson, at the New York Orthopaedic Hospital, at least ten years ago and since that time several hundred cases have been seen in that Clinic.

Its occurrence, as will be explained more fully, is dependent upon the structure of the facets of the lateral articulations. It usually causes severe pain, is disabling to a marked degree, and is but little affected by the usual methods of conservative treatment.

This study is based upon fifty-six cases which were seen at the Clinic of the New York Orthopaedic Hospital and in private practice between December 1926 and July 1933. Although the group does not constitute the entire number of such cases treated during that period, it is representative and was not selected to demonstrate any particular features. Thirty-six of the patients were males and twenty were females. The average age at which they presented themselves for treatment was thirty-one and six-tenths years, but the average age when symptoms first began was twenty-nine years. This corresponds quite closely to the age at which symptoms begin in other abnormal mechanical conditions in the lumbosacral region. The youngest patient with symptoms was nine years old, and the oldest was sixty-four. Six were less than twenty, forty were between twenty and forty, and ten were more than forty years old. Of the six patients less than twenty years old, three had symptoms and three had none, the

* At a meeting of the Halstead Club in May 1933 the subject of this paper was discussed with Dr. Robert W. Johnson, Jr., who had noted the condition and studied it quite independently.

condition having been discovered in roentgenograms taken for other reasons.

Unquestionably the most important single factor in determining a posterior displacement is the structure of the lateral articulations between the fifth lumbar and first sacral vertebrae. Trauma plays but a secondary rôle and can cause such a displacement only if a certain mechanical set-up is present. It generally is recognized that the plane of the articular facets at the lumbosacral junction is widely variable, and it has even been stated that no particular arrangement can be called normal. This, however, is an exaggeration and it can be said that in the majority of instances these articulations conform quite closely to the others in the lumbar region, the only difference being a slightly greater obliquity. The articular facets of the first sacral vertebra face internally with a slight posterior inclination and, moreover, are concave. This structure serves not only to prevent anterior displacement of the fifth lumbar and to limit rotation markedly, but it also is a very effective check upon a downward and posterior movement of that vertebra. In many individuals, however, these facets face more nearly anteroposteriorly than laterally and the articulations take the form of those in the dorsal region. In these cases the facets usually are smaller and, instead of being concavoconvex, have a flat surface. As can readily be seen by examining such a specimen, this type of joint is much less stable than the normal one and very easily permits a downward and posterior movement of the fifth lumbar on the sacrum.

It also not infrequently is found that the lateral articulations between the fifth lumbar and first sacral vertebrae are asymmetrical, one having the normal lateral and the other the abnormal anteroposterior inclination. This, too, results in a weak unstable joint which allows posterior displacement. In this group only one patient had the normal arrangement of the facets. In four the inclination was decidedly more oblique than usual and in forty-four the facets faced anteroposteriorly. Seven had a normal lateral articulation on one side and an anteroposterior on the other.

The posterior displacement is not necessarily great. Its presence in any degree is indicative of a very unstable joint and of the possibility of a temporary increase in the displacement from an unusual strain. It seems quite probable that an actual sprain of the ligaments of these joints also could be easily produced. In operations on these patients it regularly was found that the mobility of the fifth lumbar vertebra on the sacrum was much greater than normal. As measured in lateral roentgenograms, the posterior displacement was two-sixteenths of an inch in nine cases; three-sixteenths of an inch in twenty-three; four-sixteenths of an inch in eighteen; five-sixteenths of an inch in one; and seven-sixteenths of an inch in one. In the great majority some degree of posterior displacement was present regardless of the position of the patient, but in one no displacement was found in the recumbent position but it was present to an extent of one-fourth of an inch when the patient was standing. In several others the degree of displacement increased when the trunk was

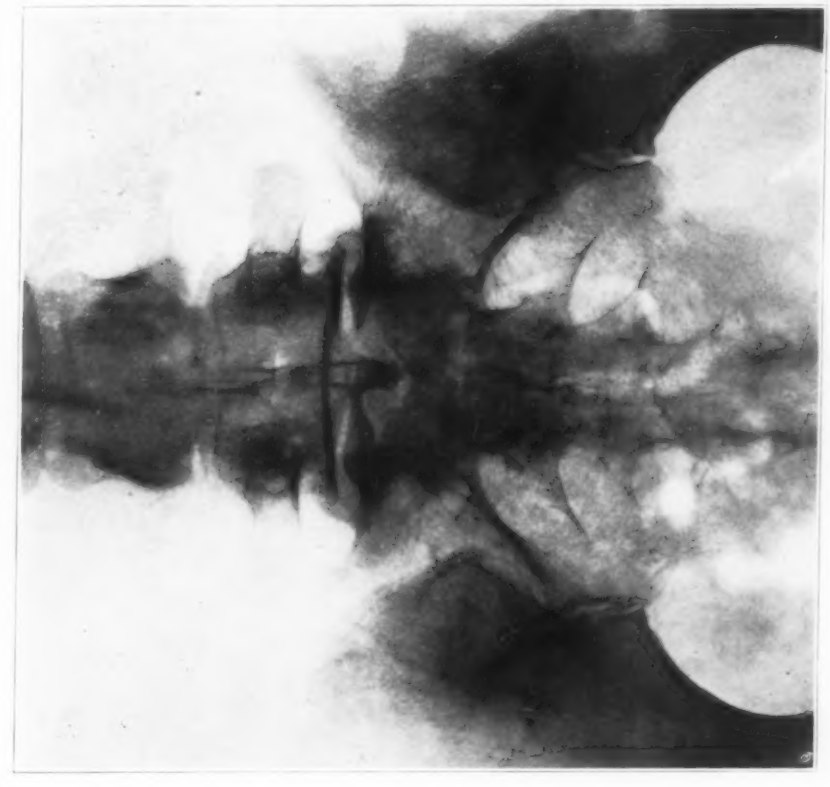

FIG. 2

Case 1. Anteroposterior facets in lumbosacral lateral articulations.

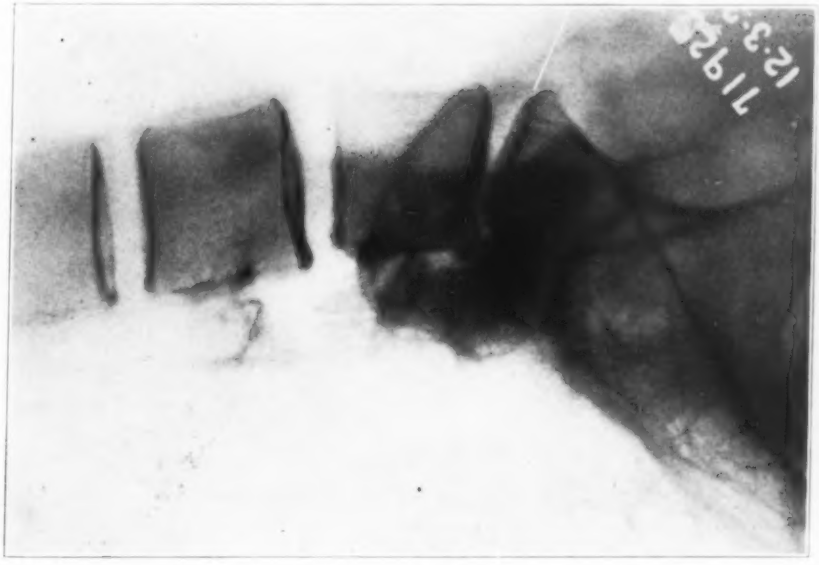

FIG. 1

Case 1. Posterior displacement of one-quarter inch. Thin intervertebral disc. Subnormal lumbosacral angle.

FIG. 3

Case 2. Posterior displacement of fifth lumbar vertebra. Thin intervertebral disc.

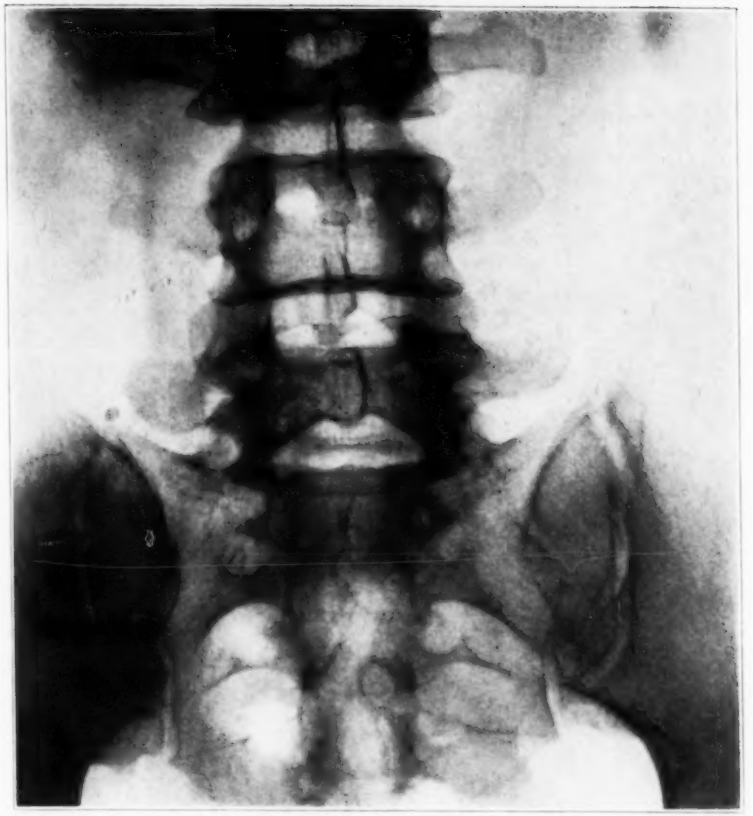

FIG. 4

Case 2. Anteroposterior type of lateral articulations.

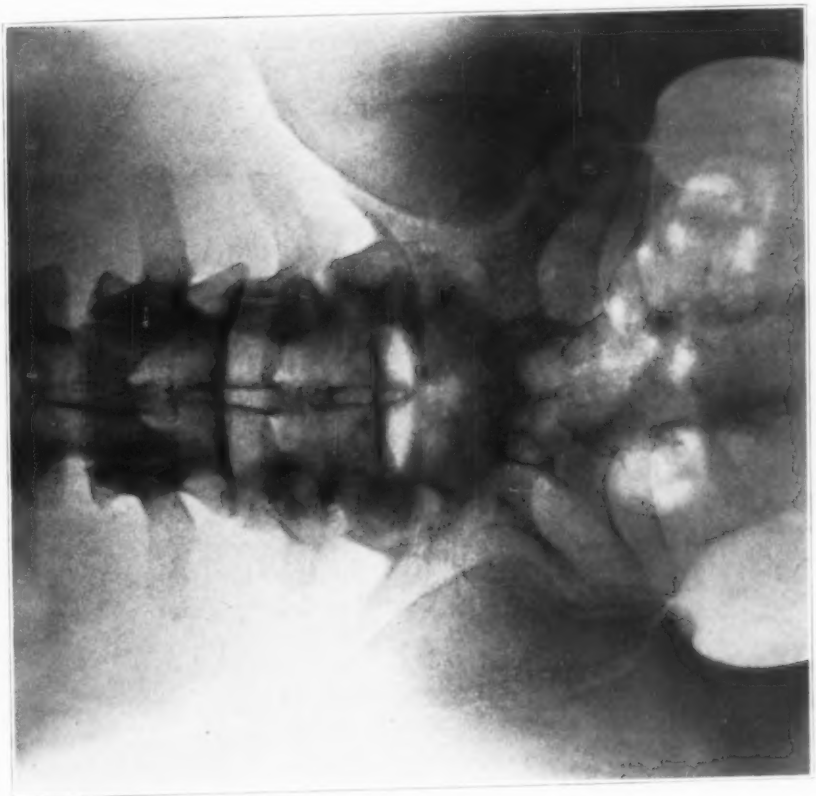

Fig. 6

Case 3. Oblique lateral articulations.

Fig. 5

Case 3. Marked posterior displacement of fifth lumbar vertebra. Acute lumbosacral angle. Intervertebral space narrowed posteriorly.

extended, and diminished or actually disappeared when the trunk was flexed. In all but one the displacement was not changed after operation. In only a few cases was osteo-arthritis demonstrable in the lateral articulations.

An important secondary factor in causing posterior displacement is diminution in thickness of the intervertebral disc, probably through rupture of the nucleus pulposus. In ten patients this condition was present. Posterior displacement is not present, however, in all cases of thinning of the disc, and oblique or anteroposterior articulations probably are a necessary concomitant. In other cases the intervertebral disc was thin posteriorly and the fifth lumbar body was tilted back on the sacrum. This occurred in the presence of an exaggerated lumbosacral angle and abnormal facets and probably an intact nucleus pulposus.

The lumbosacral angle, or inclination of the superior surface of the first sacral vertebra to the horizontal plane, averaged 37 degrees in these patients. This is 5.5 degrees less than the normal of 42.5 as computed by von Lackum [4]. Taking from 40 to 45 degrees as within the normal range of variation, it was found that twenty-nine cases had a subnormal, seventeen a normal, and ten an exaggerated lumbosacral angle.

Pain was the outstanding symptom in these patients. It was present in fifty-two of the fifty-six cases and in the majority was severe, prolonged, and disabling. As has been stated, three patients under twenty years of age had no symptoms: one, a girl of eleven, had bilateral congenital dislocation of the hip with the usual exaggerated lumbar lordosis; another, a boy of twelve, had osteomyelitis of the third and fourth lumbar vertebrae; and the third, a girl of fifteen, had a lateral curvature which did not involve the fifth lumbar. It is quite possible that at a later age these patients may develop symptoms. On the other hand, posterior displacement does give rise to pain at an early age, as evidenced by three patients of nine, sixteen, and nineteen years, respectively, who complained of severe pain. Eight others gave a history of pain commencing at from twelve to nineteen years of age. One patient, a negro porter twenty-eight years old, complained only of weakness in his back of comparatively short duration. Others mentioned that a sense of weakness had preceded the onset of pain. The duration of symptoms when the patients presented themselves for treatment varied from a few days or weeks to nineteen years, and averaged four years.

The pain was characterized by thirty patients as severe; by nineteen as moderately severe; and by two as slight. The onset was sudden in twenty-seven cases and gradual in twenty-five. The pain began definitely after an injury in fifteen. In many, however, the injury was slight,—such as lifting a heavy object—or was indefinite,—as after hard labor. The occurrence of pain after assuming certain positions,—such as bending, stooping, etc.—was frequent. The history of repeated severe attacks of pain over a number of years was common and was definitely mentioned by twenty-one patients. These attacks were often so severe as to inca-

pacitate the patient completely and necessitate his going to bed. They might last from a few days to several weeks. In the intervals an almost constant pain of lesser degree often was present. It was evident on questioning the patients that many of them had been partially incapacitated for long periods. Some had been obliged to change their occupations and others had been unable to work at all. Many had given up almost all forms of athletics and still others never had engaged in any sports because of their backs.

The pain was located in the low back in forty-seven cases, but in thirty-four it radiated to other parts. In three it was confined entirely to the course of the sciatic nerve,—*i.e.*, down the back of the thigh and the lateral surface of the leg; in three it was said to be in the buttock only. Fifteen patients stated that the pain was felt only in the low back. In one case it was in the low back and buttock; in seven, in the back and posterior part of the thigh; in twenty, in the back, posterior surface of the thigh, and lateral surface of the leg; and in four, in the back and iliac and inguinal regions. In several cases the pain was felt simultaneously in both extremities; and in others, in first one and then the other extremity. In some instances the pain occurred first in the low back, later radiated along the course of the sciatic nerve, and finally disappeared from the back, remaining only in the leg. In a few the reverse was the case. Sciatica was the predominant symptom in eight.

It thus is seen that radiation of the pain along part or the whole of the sciatic distribution was present in thirty patients. This is a striking and characteristic feature of the symptomatology in these cases and must be explained if the picture of the condition is to be complete. It is believed that the explanation lies in the concept of pressure upon the fifth lumbar root in the canal formed by the pedicles and the lateral articulation. Danforth and Wilson [5] demonstrated in a revealing anatomical study in 1925 that the fifth lumbar nerve root is relatively large and that the intervertebral foramen through which it emerges is relatively small. It cannot be supposed that a posterior displacement of the fifth lumbar vertebra, amounting to only two-sixteenths or three-sixteenths of an inch, can diminish this canal to such an extent that serious pressure is exerted upon the nerve root, but it must be remembered that in these cases the position of the fifth lumbar is unstable and that in different positions and subject to abnormal stresses the displacement in all probability becomes considerably greater at times.

If this theory is correct, it should follow that in some cases symptoms other than pain should occur. Three of these patients stated that they had weakness and numbness in one or both legs, and one had an almost complete paralysis of the muscles of the left leg supplied by the peroneal nerve, which gradually disappeared after a spinal fusion operation.

Limitation of motion in the lumbar spine, muscle spasm, and tenderness in the mid-line over the lumbosacral region were the most frequent physical findings. Relevant physical signs were absent in six patients at

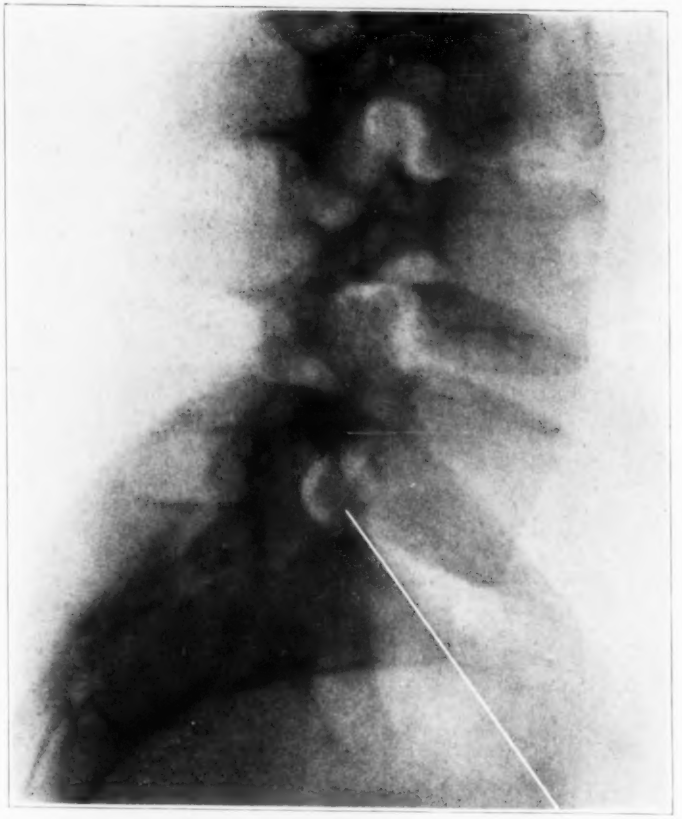

FIG. 7

Case 4. Posterior tilting and displacement of fifth lumbar vertebra. Exaggerated lumbosacral angle.

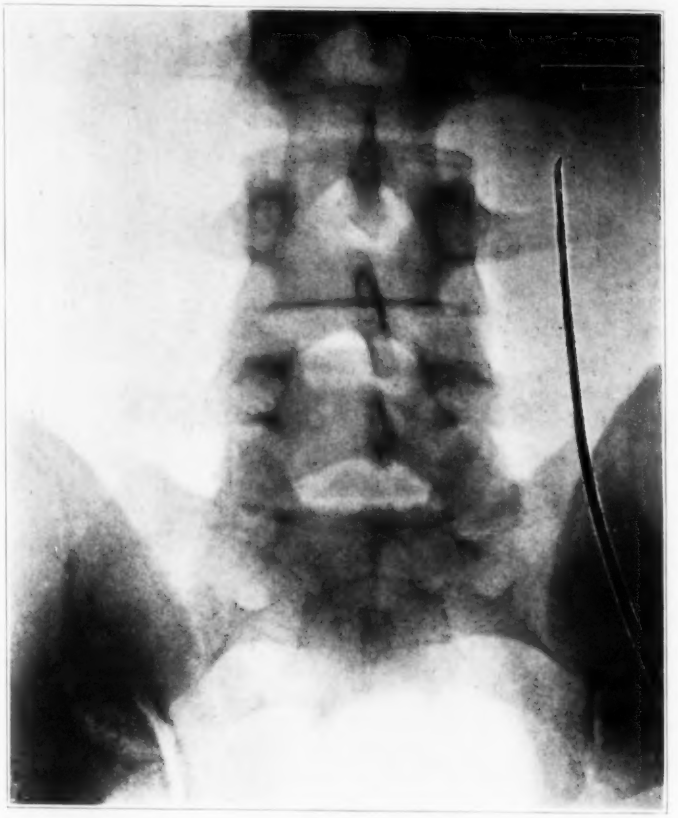

FIG. 8

Case 4. Asymmetrical lateral articulations.

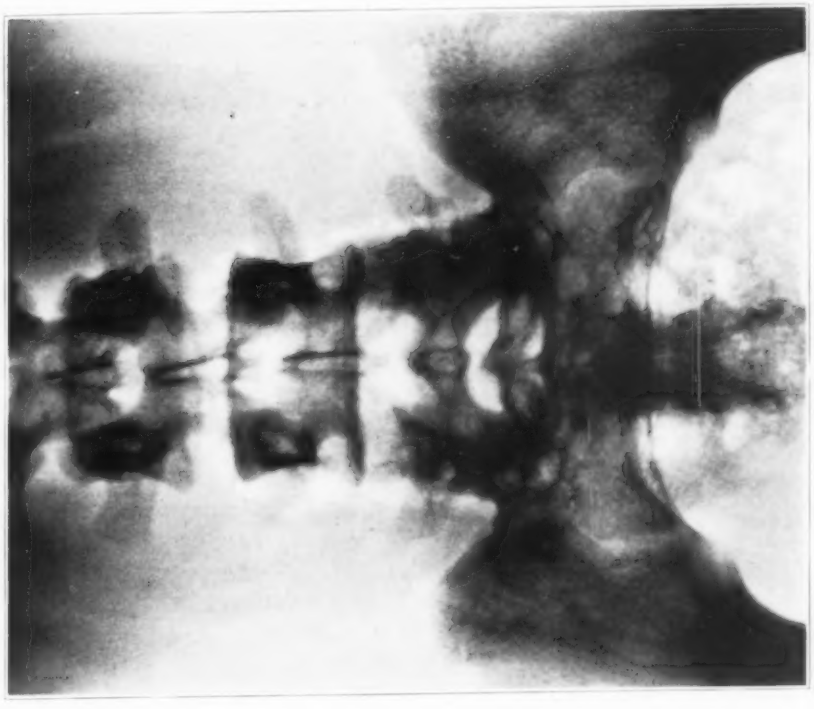

FIG. 10

Case 5. Anteroposterior lateral articulations.

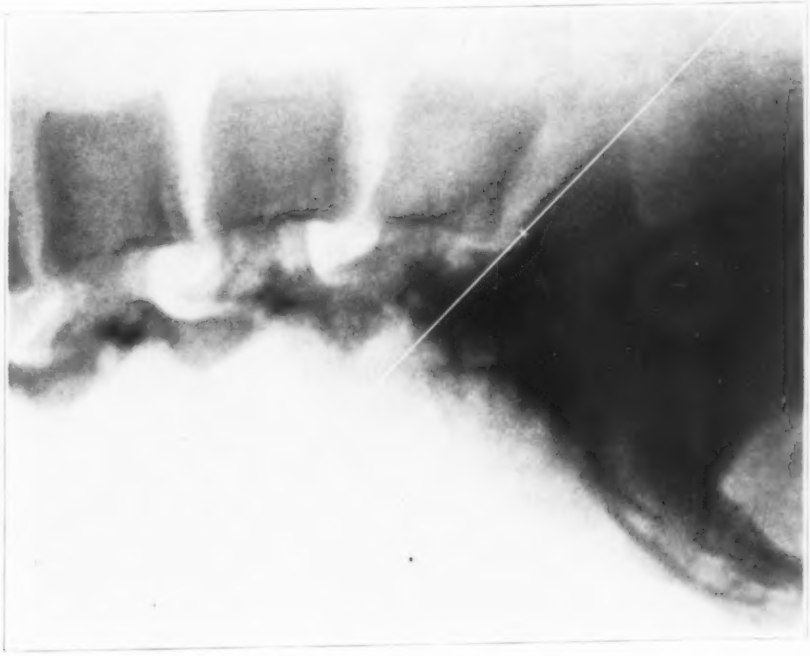

FIG. 9

Case 5. Posterior displacement of fifth lumbar vertebra of tilting type. Exaggerated lumbosacral angle.

first examination, but it should be realized that the findings vary considerably with the acuteness of the condition. Limitation of motion and spasm of the sacrospinalis muscles were present in thirty cases. Motion was painful but not limited in three. In twelve cases there was a list of the trunk to one side,—a so called sciatic scoliosis. Hyperextension and rotation of the thigh were limited and painful in four, and straight leg-raising was limited and caused pain either in the thigh or the lumbosacral region in sixteen. Tenderness was elicited at the lumbosacral junction in twenty-five patients; over one or both sacro-iliac joints in four; and over the posterior aspect of the thigh in the mid-line in two. Notably bad posture was found in ten patients.

In this connection arises the somewhat difficult question of differentiation between a lumbosacral and sacro-iliac lesion. The combination of pain radiating down the back of the thigh, tenderness over the sacro-iliac joint, limitation of rotation of the extended thigh and of straight leg-raising certainly suggests the presence of a sacro-iliac arthritis. Yet this picture was present in a number of these patients and, furthermore, the symptoms were relieved by lumbosacral fusion. A sacro-iliac fusion was done only once in this series, and that in conjunction with a lumbosacral fusion. The pain in the back and posterior part of the thigh continued after operation. It was found that the lumbosacral fusion had failed, and after this was repaired the pain disappeared and, at the last examination, five years after operation, had not recurred. It is believed that these cases definitely disprove that radiation of pain can be relied upon to differentiate sacro-iliac from lumbosacral conditions, and indeed, in our experience, in the majority of cases radiating pain of the type that by many is regarded as typical of a sacro-iliac arthritis has been caused by a lumbosacral lesion.

Thus a fairly definite clinical picture is found in many cases of posterior displacement of the fifth lumbar vertebra, including a history of low back pain with radiation to the back of the thigh and outer side of the leg, recurring in acute attacks; tenderness over the lumbosacral region; muscle spasm and limitation of motion; and often a lateral list of the trunk. The decisive and most important factor in the diagnosis, however, is the roentgenogram. This must include a good lateral view which is taken exactly in the lateral plane. A slight shift of the tube is enough to produce the appearance of a posterior displacement when none exists or to conceal the presence of one. A lateral view with the patient standing and others with the trunk flexed and extended, taken by the technique developed by Ferguson, have also been found very useful. Such roentgenograms should be taken in all cases in which a posterior displacement is suspected.

Nine patients either came for consultation only or sought other advice after the first examination and therefore received no treatment. Three were not treated because they had no symptoms, the displacement having been discovered by accident. Twenty-one patients were treated by

conservative measures only. Twelve received conservative treatment followed later by lumbosacral fusion, and seven had lumbosacral fusion without other preliminary treatment. By conservative treatment is meant rest on a hard bed in very acute cases, heat, massage, and exercises, the latter directed particularly toward correction of posture. These measures usually were combined with either a belt or brace, or, in women, with the use of a corset with back pad. An effort was made to reduce the weight of obese patients, chiefly by diet. Probable sources of infection—such as infected teeth and tonsils—were eliminated, but an effort was made to maintain a common-sense point of view and to avoid a ruthless sacrifice of these structures.

The results of treatment could not be determined in thirteen cases, because of the failure of these patients to carry it out at all or for a sufficient length of time. Eighteen patients treated conservatively were followed for less than one year. One of this group was completely relieved of symptoms. Thirteen were partially relieved, the majority only slightly; and four were unimproved. Three patients treated conservatively were under observation for more than one year. One was entirely free from pain and the other two received practically no relief. Lumbosacral fusion was done on twelve patients who failed to receive sufficient improvement after other methods of treatment. Operation was advised for ten others, but was refused. It is quite certain that, had they remained under our care, more would have been advised to have a fusion operation after it was demonstrated that results could not be obtained by conservative means.

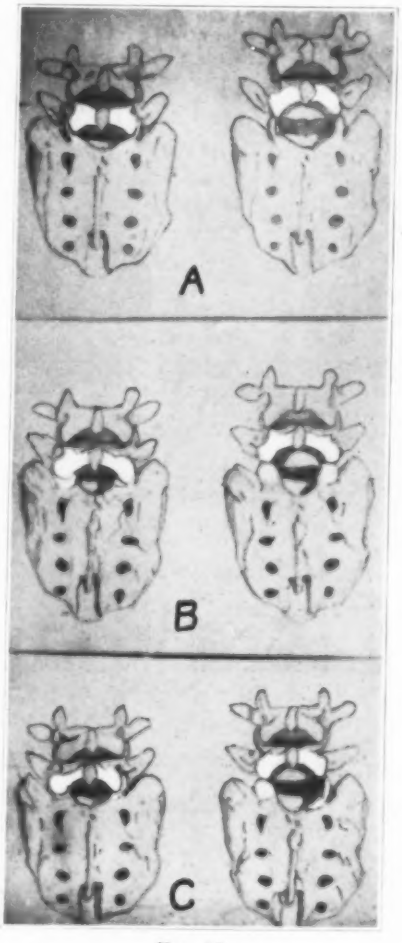

FIG. 11

Types of lateral articulations: *A*, normal lateral; *B*, anteroposterior; *C*, asymmetrical. Types *B* and *C* permit posterior displacement.

In all, nineteen patients had lumbosacral fusions by the Hibbs technique and, as was stated, a sacro-iliac fusion was done in one case. Twelve of these patients had had conservative treatment in our Clinic before operation was resorted to, and the other seven had been treated elsewhere. The average duration of symptoms before operation was five and three-

tenths years, and varied from one and five-tenths to ten years in individual cases. Thirteen patients, or sixty-eight and three-tenths per cent., were completely relieved by operation; five, or twenty-six and three-tenths per cent., were much improved; and one, or five and three-tenths per cent., was unimproved. This last patient was a young woman in whom a pseudarthrosis or failure of fusion occurred. She had exhibited a very unstable nervous system and afterwards developed a typical case of major hysteria, for which she was treated at the New York Neurological Institute. Bony fusion after operation failed to occur in one other patient, but was effected by a second operation, after which the symptoms completely disappeared. Of the group designated as improved, two had pain throughout the back, arms, legs, etc., subsequent to operation, which was believed to be due to arthritis; and three had slight recurrences of back pain after operation, but were greatly improved and were able to return to work. The average period of observation after operation was two and eight-tenths years.

CONCLUSIONS

1. Posterior displacement of the fifth lumbar vertebra occurs frequently and is an important cause of severe back pain.

2. The displacement happens as the result of an anatomical variation in the facets of the lateral articulations between the fifth lumbar and first sacral vertebrae.

3. Sciatica is of frequent occurrence because of pressure on the fifth lumbar nerve root.

4. Conservative measures seldom cure the symptoms from posterior displacement of the fifth lumbar and, in the majority of cases, lumbosacral fusion is the only effective means of treatment.

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THOUGHTS ON THE RELIEF OF SCIATIC PAIN

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The writer is prompted to record two case histories and to suggest for consideration a conservative operative treatment for the relief of so called sacro-iliac or sciatic pain. There has been no anatomical research preceding these observations, and this report is presented only as a suggestion that perhaps the pain commonly attributed to the sacro-iliac joint does not necessarily arise from a joint lesion, but may arise as a result of an abnormality in the soft structures in that vicinity. In spite of the frequency of sciatic pain and the enormous amount of literature on the subject, there is no agreement as to the accuracy of diagnosis which places the seat of the trouble at the sacro-iliac joint. Perhaps the most valuable single localizing sign accompanying a sacro-iliac lesion is the presence of tenderness localized over the sacro-iliac ligaments.

Any orthopaedic surgeon in dispensary and private practice sees a large number of patients with disability diagnosed as sacro-iliac strain or arthritis. We have been taught methods of localizing a lesion at the sacro-iliac joint, and how to differentiate between a sacro-iliac and a lumbosacral lesion. Accurate localization is not always possible, but becomes necessary if one is to recommend the radical treatment of arthrodesis. It goes without saying that, if we are to attempt to relieve symptoms in a joint by arthrodesis, we must be certain beforehand of which joint to fuse.

It is admitted that arthrodesis of the sacro-iliac joint is followed by a complete and lasting relief of symptoms, and by no means must this communication be interpreted as decrying this procedure. However, observations common to all of us make one doubt that a sacro-iliac lesion is necessarily the usual cause of sciatic pain. Difficult to reconcile are the following:

1. Tuberculosis of the sacro-iliac joint does not commonly cause acute pain. Here we have a destructive joint lesion which, in other parts of the body, is characteristically painful and is accompanied by muscle spasm. It is a common observation in proven cases of tuberculosis of the sacro-iliac joint, with gross destruction seen in the roentgenogram, and even with a large abscess, that acute pain and tenderness are not characteristic symptoms of this disease.

2. The author has observed a patient with a true dislocation of a sacro-iliac joint resulting from a severe crushing injury to the pelvis, and has been surprised by the comparative freedom from the pain usually ascribed to a lesion of the sacro-iliac joint.

3. The practically immediate relief from pain following arthrodesis of the sacro-iliac joint by the Smith-Petersen or Campbell method is the rule rather than the exception. The author has often been struck by this

fact on the day following operation. Surely the prompt relief could not result from joint fixation alone. It is conceivable that this would be possible following the Smith-Petersen method, where a mortise of bone is countersunk into the sacrum, but there could be no such explanation following the extra-articular bone-chip method of Campbell. The author has proven to his own satisfaction in several cases that relief of pain is not the result of postoperative fixation in plaster, since in these cases no form of fixation whatever was applied immediately following operation. Again, most of the patients on whom the writer has operated have previously had rest in bed, with traction or fixation in a plaster spica. On the day following operation, when the joint is entered with the necessary involvement of trauma, one would expect more pain, more marked limitation of straight leg-raising, and pain on compression of the iliac crests. Yet this is not the case. Is it not possible, therefore, that something other than arthrodesis is accountable for the absence of signs and relief of pain? It cannot be explained by Freiberg's conception,[1] since operative approach was nowhere near the piriformis muscle nor the sciatic nerve.

4. When one considers the distance of the sacro-iliac joint and ligaments from the surface of the body, it is difficult to conceive how a comparatively light pressure of the thumb at this region will elicit the marked degree of pain in many patients, if this pain arises within the sacro-iliac joint. Surely one cannot bring about an increase in the intra-articular pressure or irritate the synovial membrane or joint capsule by this palpation over structures so deeply situated. It may be true that there is an hyperaesthesia of the skin corresponding to the same nerve segment that innervates the joint.

5. Manipulation under anaesthesia is followed by relief of symptoms in a sufficiently large number of cases to indicate that the cause of symptoms is extra-articular. The author does not believe that manipulation relieves by reducing a subluxation.

With these points in mind, the following case reports are presented.

CASE 1. R. I., a man forty-five years of age, was first examined by the author on December 30, 1932. For three months he had been complaining of severe pain in the region of the right sacro-iliac joint. The pain radiated down the posterior aspect of the thigh to the knee, and was constant day and night. He had been under the care of Dr. Harold Conn, of Akron, who had found it necessary to administer sedatives because the usual palliative measures of treatment had afforded no relief.

About three years previously the patient had suffered with pain of a similar nature in the left side. An arthrodesis of the left sacro-iliac joint was done according to the method of Smith-Petersen, and was followed by complete and lasting relief from pain on that side. Unfortunately, however, the wound subsequently became infected and a sinus persisted in spite of the removal of the bone plug and curettage of the hole in the ilium.

On examination, there was acute local tenderness just medial to the posterosuperior spine and between this process and the spinous process of the fifth lumbar vertebra. There was also tenderness, but not acute, over the middle of the right buttock posteriorly. Straight leg-raising was limited to forty-five degrees, and caused acute pain in the region of the sacro-iliac joint. Compression of the iliac crests did not cause acute

pain, but resulted in moderate discomfort. There was no list. When standing, there was a distinct limitation of forward bending, and, when sitting, there was also a slight limitation in backward bending, with pain immediately to the right of the lumbosacral joint. Lateral bending was not limited or painful. There was no atrophy of the buttock or thigh. There was no disturbance in sensation, and the knee and ankle jerks were normal.

Roentgenographic examination revealed nothing abnormal except the old operative fusion of the left sacro-iliac joint, with an increased bone density about that region. There was no sequestrum demonstrable.

The physical examination indicated a lesion presumably at the right sacro-iliac joint, but in some respects indicated a lesion at the lumbosacral joint. It was felt that an operation to fuse the right sacro-iliac joint, and possibly the lumbosacral joint as well, was indicated. However, such a procedure would be inadvisable in view of the infected sinus with a chronic osteomyelitis already existing on the left side.

It was, therefore, proposed to the patient that a simple muscle-and-ligament-stripping operation be done (to be described later in this paper). He was told that this procedure had never been done before, and was made to understand that it was in the nature of an experiment. If an operative infection developed because of contamination from the sinus on the left side, it would be easily controlled and would not result in an osteomyelitis since the operation would be confined entirely to the soft parts. Immediately after closure of the wound a radical operation would be done on the left side in an attempt to cure the chronic osteomyelitis.

The operation was done on January 5, 1933. A curved incision was made along the posterior third of the crest of the ilium, with complete exposure of the posterosuperior spine. All ligamentous and muscular attachments were dissected away subperiosteally, and the wound was closed in layers, approximating the soft structures to their normal attachments. Immediately, another long incision was made over the left side in order to treat radically the chronic osteomyelitis of the ilium. This wound was packed open with vaselin gauze. The patient was returned to bed with no postoperative fixation or traction, and was instructed to lie in the most comfortable position.

Previous to the operation, the patient had been requiring sedatives in order to rest at night. Following the first postoperative day he was comfortable, and felt no pain similar to that experienced before operation. He was kept in bed for two weeks, chiefly because of the rather extensive operation for the cure of the chronic osteomyelitis, and was discharged as an ambulatory patient nineteen days after operation. The operative wound on the right side healed by first intention.

At the time of this report, June 1934, the patient is free from pain and has had no particular discomfort since his operation. Incidentally, the wound resulting from the operation for osteomyelitis of the ilium has been healed since June 1933.

This patient, then, had been suffering with severe constant pain for three months. According to his story, it was the same type of pain that he had had previously on the left side, and which had been relieved by arthrodesis of the left sacro-iliac joint. The orthopaedic surgeon in charge again made a diagnosis of a lesion of the sacro-iliac joint, and, on subsequent examination by the author, the patient presented symptoms and signs of a sacro-iliac lesion. It is important to emphasize the fact that the patient is intelligent, and that every effort was made before and after operation to avoid any suggestive therapy. He was told frankly that the operation proposed had never been done before, and that there was only a remote possibility of its relieving his symptoms.

Case 2. Mrs. C. H., a woman thirty-five years of age, was first examined on June 12, 1926. For a year prior to examination she had been complaining of pain in the re-

gion of the left sacro-iliac joint. The pain radiated down the posterior aspect of the left thigh and leg. She was most uncomfortable when lying on her back, and when turning over in bed. At times she had a slight stiffness in the elbows and knees. There was no history of injury.

Examination revealed acute tenderness over the left sacro-iliac joint and deep in the soft structures immediately below the postero-inferior spine. Straight leg-raising was slightly limited and painful on the left side. There was no pain on compression of the iliac crests, and no limitation of motion in the spine. There was no list. The circumference of the left thigh measured one inch less than that of the right. There was no sensory disturbance, and no alteration of either the knee jerks or ankle jerks.

A sacro-iliac belt failed to relieve the symptoms, and a forcible manipulation under general anaesthesia, on October 21, 1926, relieved the symptoms for only three days. After a consultation with Dr. T. A. Willis, arthrodesis of the left sacro-iliac joint was agreed upon. This operation (Smith-Petersen) was done on November 11, 1926. Following operation, the patient continued to have considerable discomfort, with pain radiating down the leg as before. She was discharged from the hospital on November 27, 1926.

While at home, the patient continued to have pain referred down the thigh and more than usual local tenderness. Since she had no relief of symptoms, was very uncomfortable, and a small sinus persisted, the possibility that a sponge had been left in the wound was considered. She was, therefore, readmitted to the hospital in order that the wound might be explored.

On March 21, 1927, the wound was opened and explored but no sponge was found. It was then decided to strip the ligaments from the posterosuperior spine inferiorly and medially. This was done subperiosteally and the wound was closed. The patient was returned to bed with no postoperative fixation. She felt better immediately.

This patient was last heard from in 1933, six years after operation, and during that time she has had no recurrence of symptoms.

In this case, a diagnosis of sacro-iliac pain was made by two orthopaedic surgeons who recommended arthrodesis of the sacro-iliac joint. This operation, however, failed to give relief from pain. Following a secondary subperiosteal stripping of the long and short posterior sacro-iliac ligaments, pain was promptly relieved and has not recurred during six years. It is admitted that this proves nothing, but it is suggestive.

In view of the gratifying results obtained in these cases, similar treatment is suggested in cases of chronic or long standing sciatic pain, with local tenderness at the site of the sacro-iliac joint, when these symptoms cannot definitely be ascribed to a lesion of the sacro-iliac or lumbo-sacral joint.

OPERATION

The operation proposed consists of a curved incision following the posterosuperior spine and extending to the postero-inferior spine; this incision is carried down to bone. The iliac origin of the gluteus maximus muscle, arising from the lateral lip of the crest of the ilium and from the posterosuperior spine, is pushed aside subperiosteally down to the superior gluteal line of the ilium, and the dissection is carried down to the upper margin of the great sciatic notch. The subperiosteal dissection is then continued along the medial surface of the posterosuperior spine to the sacrum, and inferiorly to the postero-inferior spine. In this way, the posterosuperior spine and the lateral aspect of the posterior third of the

ilium are completely denuded of ligamentous as well as muscular attachments. This completes the operation, and the wound is closed. No postoperative fixation is recommended. If the results obtained in the two cases reported are confirmed by others, the usefulness of this operation is obvious. It is quickly done and convalescence is short.

RATIONALE

The dissection described releases the iliac or upper origin of the gluteus maximus muscle, or that portion which is inserted chiefly into the fascia lata. It also removes a portion of the iliac attachment of the short and long posterior sacro-iliac ligaments. Theoretically, it may relieve pain in two ways: (1) by releasing the tension of the muscle and the strain at the site of the muscular or ligamentous attachments; (2) by relieving muscle spasm.

1. Attention is called to Sir Robert Jones's conception[2] of a strain of a muscle attachment which is diagnosed by the presence of pain when the muscle is actively contracted against resistance, or when it is passively stretched. Usually there will be found a localized area of tenderness at the insertion of the tendon. "This tender spot is the key to the situation. It is a small patch of effusion below the periosteum to the bone. . . . The pain is due to the tension on this effusion caused by tension on the muscle, or by direct pressure on the oedematous spot." It is, therefore, conceivable that subperiosteal dissection of muscle from its bony attachment may relieve local pain.

2. According to Llewellyn and Jones,[3] fibrositis or myositis may be the result of infection, toxin, or trauma. There is a fibrositis or hyperplasia of the connective tissue in the muscle, which is seen most commonly in attacks of lumbago, acute wry or stiff neck. They believe that infection or trauma make the sense organ located in the tendons hypersensitive. There is, therefore, an increased muscle tone and, in the acute case, a collapse of the veins which are more compressible than the arteries. The engorgement of blood into the muscle causes swelling and heat. In the chronic case, the circulatory stasis stimulates an overgrowth of fibrous elements. Here again, it is conceivable that subperiosteal dissection will relieve the pain caused by a fibrositis by relieving muscle spasm with improvement of circulation in the muscle. The writer cannot explain why this operation would relieve pain referred down the thigh any better than he can explain why the pain of a subdeltoid bursitis is referred to the insertion of the deltoid, or why the pain of a radio-ulnar bursitis radiates down the forearm.

CONCLUSIONS

Since sciatic pain was relieved promptly and permanently by subperiosteal stripping of the gluteus maximus muscle and ligaments from the posterosuperior spine of the ilium in the two cases here reported, the method is worthy of consideration. Two cases, of course, prove nothing,

but they are provocative of thought. There appears to be scientific basis for the method, although this is not well understood. It is understood, of course, that the author does not deny the existence of an intra-articular sacro-iliac lesion, to which this method does not apply.

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A NEW ATTEMPT AT TREATMENT OF CHRONIC OSTEOMYELITIS *

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An area of aseptic bone necrosis anywhere in the skeletal system may be advantageously treated by connecting the necrotic segment with an adjacent living segment of bone by means of drill channels.

The author feels that the formulation of this working principle is fairly justified by the satisfactory results obtained after its application in cases of Legg-Calvé-Perthes disease, osteochondritis dissecans, Osgood-Schlatter disease, intracapsular fractures of the neck of the femur, slipping and slipped upper femoral epiphyses; in all of these conditions aseptic bone necrosis is the main pathological feature.

The observations of Axhausen [1], Phemister [2], Santos [3], Freund [4], and Cordes [5] have definitely established that the essence of the spontaneous healing process of aseptic bone necrosis, brought about by any cause, is the substitution of living bone in the place of necrotic bone, effected by the slow penetration of tissue elements and capillaries of the adjacent living bone.

The drilling of channels into the necrotic area presents nothing but the breaking of broad avenues to facilitate this invasion by new vessels.

In addition to the cases already presented (case reports published and under preparation for publication [6, 7]), the author wishes to submit a case of aseptic bone necrosis which may well illustrate the effectiveness of this principle.

CASE 1. E. G. (No. 25658), a five-year-old boy, was admitted to the Morrisania City Hospital, December 14, 1931, because of inability to use the right lower extremity. The onset of the condition had been gradual. There was a history of several small accidents, while at play during the summer, but no outstanding trauma. Motion in the right hip joint was somewhat limited in every direction, but there was no marked degree of pain. The child was not able to stand on his right leg, had a very marked limp, and was reluctant to walk. He sought support by leaning against nearby objects or persons, and, in their absence, lay down. There was no temperature.

The roentgenogram of the right hip (Fig. 1), taken on December 10, 1931, in the Out-Patient Department, reveals a large subcapital segment, fragmented or sequestrated off the femoral neck. Without attempting to classify the condition exactly, it was felt that it belonged in the aseptic-necrotic-degenerative group of lesions. After eight days during which there was no fever, a drilling operation was performed on December 22, 1931. Two channels were drilled,—one in the axis of the neck, penetrating toward the head; the other into the affected segment. The limb was immobilized.

Roentgenographic examination, January 28, 1932, five weeks after operation, showed union of the detached segment with the neck and the filling out of its irregular edges to a smooth, normal outline (Fig. 2). The two drill channels are visible.

*Read before the Clinical Society of the Hospital for Joint Diseases, December 5, 1933.

FIG. 1

Case 1. Roentgenogram, December 10, 1931. Large sequestrum of the femoral neck.

FIG. 2

Case 1. Roentgenogram, January 28, 1932, five weeks after operation. Sequestrum fused to neck in somewhat displaced position. Two drill channels visible.

FIG. 3

Case 1. Roentgenogram, January 12, 1933, one year after operation. No indication of pathological changes.

The roentgenogram (Fig. 3), taken January 12, 1933, one year after operation, shows no pathological changes. The child has been seen at regular intervals and the follow-up during the course of two years has shown no indication of any disturbance.

While attempting to compare the characteristic features of aseptic bone necrosis and necrosis in the wake of septic processes such as suppurative osteomyelitis, the author has been obliged to come to the conclusion that, in spite of the seemingly great discrepancies, in the last analysis no difference exists.

The clinical and experimental observations of F. W. Bancroft [8] on hematogenous osteomyelitis demonstrated that the substitution process is just as active in the recovery of these septic necroses as in the aseptic necroses. This circumstance, rather than the supposed attenuation of the infection, is the reason, in the author's opinion, for the good results obtained from the simple drill-hole evacuation of chronic bone abscesses recommended by Brickner [9].

Since the natural healing process in both aseptic and septic necrosis appeared to be analogous, it seemed possible that septic necrosis might respond favorably to the treatment that was found effective in aseptic necrosis.

The author attempted to induce substitution and revitalization of necrotic areas of bone in chronic osteomyelitis by connecting these areas with living bone segments by means of saw cuts and drill channels. The procedure in the first two cases—observed one and three-quarters years and one year after operation, respectively—proved successful.

Case 2. A. M. (No. 31449), a schoolboy, aged twelve years, came under observation for chronic osteomyelitis in the fall of 1930. Subsequent to an incision, a discharging sinus developed on the flexor surface of the left mid-thigh. Roentgenographic examination, made on February 7, 1931, revealed a large abscess cavity close to the lower epiphyseal line of the left femur and a perforation of the cortex on the posterior surface of the femur (Figs. 4 and 5).

The patient was immediately admitted to the Hospital for Joint Diseases and a saucerizing operation was performed which laid the abscess cavity wide open as seen in the roentgenogram (Fig. 6), taken February 14, 1931. The wound closed, but the original sinus continued to discharge. For fifteen and one half months this condition prevailed, during which time the musculature of the left thigh diminished considerably. The configuration of the limb became fusiform with maximum circumference at the knee, due to the persisting oedema of the lower thigh and popliteal region. There was no effusion in the knee joint. Flexion in the knee was considerably limited. The child was unable to take part in the physical training class.

On May 7, 1932, roentgenographic examination revealed the persistence of the abscess cavity previously observed (Figs. 7 and 8). A segment of bone bordering the cavity appeared structureless and denser than the rest of the bone and was considered necrotic. There was a small sequestrum close to the site of the cortical perforation, some three inches distal to the sinus opening in the skin. In the popliteal region there was a large collection of pus which drained poorly through the opening situated very much higher.

The patient was admitted to the Wickersham Hospital on May 27, 1932, and an operation was performed by the author. An incision was made in the old scar, leaving the sinus untouched. A large abscess cavity was found under the vastus lateralis, the bottom of which was formed by the femoral cortex which lacked periosteal covering.

FIG. 4

Case 2. Roentgenogram, February 7, 1931. Abscess cavity near epiphyseal line.

FIG. 5

Case 2. Lateral view of Fig. 4. Abscess cavity and cortical perforation on shaft.

FIG. 6

Case 2. Roentgenogram, February 14, 1931. Operative exposure of abscess cavity.

In this denuded area the cortical perforation was identified, and, on probing, was found to lead toward the cavity in the bone. No search was made for the sequestrum visible in the roentgenogram. In the denuded area of the femur several channels were drilled

FIG. 7

Case 2. Roentgenogram, May 7, 1932. Cavity persistent. Structureless dense necrotic area next to cavity.

FIG. 8

Case 2. Lateral view of Fig. 7. Cavity and site of cortical perforation; small sequestrum in sinus.

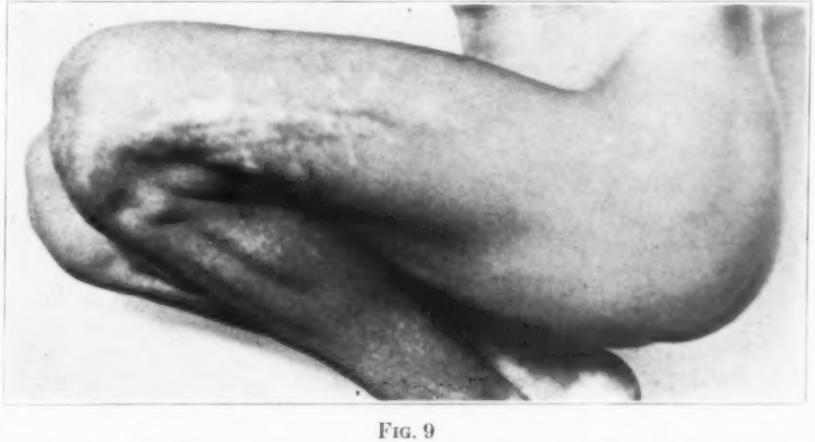

FIG. 9

Case 2. Photograph taken one and three-quarters years after operation. Maximum flexion at knee. Scar not adherent. Good muscular development.

transversely or obliquely to the axis of the shaft and the depth was so calculated that they might penetrate beyond the supposedly necrotic area into living bone. This living bone was considered to have been reached when fresh blood welled up out of the channel. In the same area, a longitudinal cut, two inches in length, was made with an electric circular saw. The incision was loosely packed with iodoform gauze. The patient was hospitalized for eight days during which no rise in temperature, no inflammatory reaction of the wound, and no effusion in the knee joint were observed. From the date of discharge, June 4, 1932, the patient was ambulatory.

The operative wound healed rapidly. The sinus continued to discharge for about eighteen weeks, evacuating spontaneously several minute sequestra. Clinical examination at the end of this time showed the sinus to be definitely closed.

The patient was seen at regular intervals, and the oedema of the thigh and knee gradually disappeared. With increasingly vigorous use of the limb, full flexion of the knee was reached in about nine months. One and three-quarters years after operation, the muscular condition of the limb, as seen in Figure 9, was good. The scar was not adherent to the bone or to the deep tissues. There was maximum flexion in the knee joint. Palpation of the region operated upon showed no tender spots.

The roentgenograms (Figs. 10 and 11), taken June 16, 1932 and January 4, 1933, respectively, show gradual obliteration of the cavity and reconstruction of the femur. In Figure 10 the saw cut and one of the drill channels are visible.

The last roentgenographic examination (Figs. 12 and 13), made on February 9, 1934, revealed almost complete obliteration of the cavity, marked return to normal of the bone structure, disappearance of surface irregularities, and absence of such structural disturbances as would indicate the probability of an impending recurrence.

Case 3. L. R. (No. 34051), male, twenty-six years old, a salesman, gave a vague history of blunt trauma to the left thigh. He had experienced some discomfort, with increasing swelling and tenderness of six months' duration. Three weeks prior to examination he became ill and was unable to walk.

The patient was admitted to Morrisania City Hospital on November 2, 1932. Examination showed the left thigh to be considerably swollen and tender. There was no temperature.

The roentgenogram (Fig. 14), taken November 18, 1932, shows marked structural irregularities of the left femur, indicative of chronic osteomyelitis with possible medullary abscess.

On November 21, 1932, an operation was performed during which a large window was cut into the cortex, pus was evacuated, and all necrotic bone was removed. (Culture of the pus was sterile for forty-eight hours.) The wound healed rapidly.

Two months later, the patient was readmitted to the Hospital. The site of the previous operation was found to be considerably swollen and tender; a small capillary sinus was present. Roentgenographic examination on January 24, 1933 (Figs. 15 and 16) revealed the window in the cortex, production of some new bone, and indications of sequestration of portions of the cortex.

An operation was performed by the author on January 25, 1933. Approach was made through the old incision. A large abscess containing several ounces of pus (bacillus coli on culture) was found surrounding more than half of the femoral shaft. No loose sequestra were found. The edges of the previously made window were, in places, denuded of periosteal covering. Two longitudinal cuts were made with the circular saw into the upper and lower borders of the window, extending well beyond the denuded area. None of the necrotic portions was removed. Into the sides of the window several small channels were drilled. The wound was loosely packed with iodoform gauze and the limb was immobilized in plaster splints to prevent fracture at the site of the window.

The postoperative course was entirely afebrile. For social and economic reasons the patient was kept in the Hospital for thirty days. After discharge, he did not reappear until June 7, 1933, eighteen weeks after operation, when the wound was found to be firmly healed.

FIG. 10

Case 2. Roentgenogram, June 16, 1932. Saw cut and one drill channel visible.

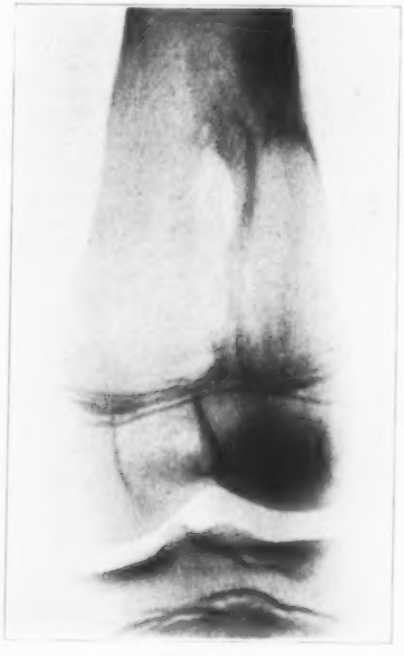

FIG. 11

Case 2. Roentgenogram, January 4, 1933. Gradual obliteration of cavity.

FIG. 12

Case 2. Roentgenogram, February 9, 1934. Cavity almost obliterated. Structure of bone normal. No surface irregularities.

FIG. 13

Case 2. Lateral view of Fig. 12. No surface irregularities. Bone structure normal. No trace of cavity. One drill channel visible.

FIG. 14

Case 3. Roentgenogram, November 18, 1932. Marked structural irregularities with indication of medullary abscess.

FIG. 15

Case 3. Roentgenogram, January 24, 1933. Anteroposterior view of shaft with operative window. Indications of necrosis of cortex.

FIG. 16

Case 3. Lateral view of Fig. 15.

FIG. 17

Case 3. Roentgenogram, December 1, 1933. Window markedly diminished in size. Normal bone structure considerably reestablished.

FIG. 18

Case 3. Lateral view of Fig. 17.

FIG. 19

Case 3. Photograph taken one year after operation. Wound healed. Muscular condition good.

The patient was followed up at irregular intervals. He was seen December 1, 1933, one year after operation. As shown in Figure 19, the wound was firmly healed. The muscular condition of the limb was satisfactory. There was flexion in the knee considerably beyond a right angle, but not yet maximum. No oedema was present at the site of operation. Through the operative hiatus in the fascia lata the femur was palpable; there was no tenderness. Figures 17 and 18 show the window to be considerably diminished in size, the normal structural picture to be fairly well reestablished, and no indication of an impending recurrence. Figures 20 and 21, roentgenograms taken August 28, 1934, show almost complete restitution of the defect in the shaft.

FIG. 20

Case 3. Roentgenogram, August 28, 1934. Almost complete restitution of the defect in the shaft.

FIG. 21

Case 3. Lateral view of Fig. 20.

It is obviously beyond the scope of this article to discuss chronic osteomyelitis in all its phases. Such discussion would, in fact, be premature until more progress has been made in the clarification of the laws governing the multiform manifestations of this disease in cancellous and cortical bone as predetermined sequelae to an acute attack, to blunt trauma, to a fracture, or to suppuration of the adjacent soft parts. It is hoped that with the aid of new experiences and the reevaluation of the old ones there may be a better understanding of such questions as the tendency to spontaneous healing,

the reasons for chronicity, the mechanism of the so called recurrences, sequestration, and necrosis without sequestration.

The author believes that by trial along the lines of the described procedure a treatment may be evolved for chronic discharging osteomyelitis—or, rather, osteonecrosis—that will not necessitate the extensive operations that are in vogue at present.

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CONGENITAL DISLOCATION OF THE HIP STRETCHED BY MEANS OF A TURNBUCKLE CAST

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In certain cases of congenital dislocation of the hip of long standing, where the hip is riding very high above the rim of the acetabulum, it is often desirable to attempt to pull the head of the femur down, so that it will approximate or nearly approximate the acetabular cavity. Ordinary Buck's extension does not give sufficient traction to accomplish this result. The use of the so called well-leg splint has not, in our hands, given sufficient leverage for pulling down these resistant hips.

We have found, however, that by means of a special plaster-of-Paris cast (Fig. 1), we have been able to accomplish an approach to reduction by traction alone. The following technique is used:

Traction is exerted in the axis of both lower extremities with the object of stretching the dislocated hip as much as possible before applying the cast. A double spica cast is then applied with the patient lying on an ordinary fracture table; this need not be a heavy cast. If the plaster bandages are rubbed in carefully and thoroughly, a light-weight cast of even thickness can be made which will be not only strong, but at the same time comfortable for the patient. The turnbuckles (*A* and *B*) are incorporated into the cast as shown in Figure 1. In addition to these turnbuckles, a cross-beam (*C*) with swivel attachments at either end (*D* and *E*) is imbedded in the cast. This prevents rotation of the extremity and maintains the position of abduction. The roller attachment (*F*) elimi-

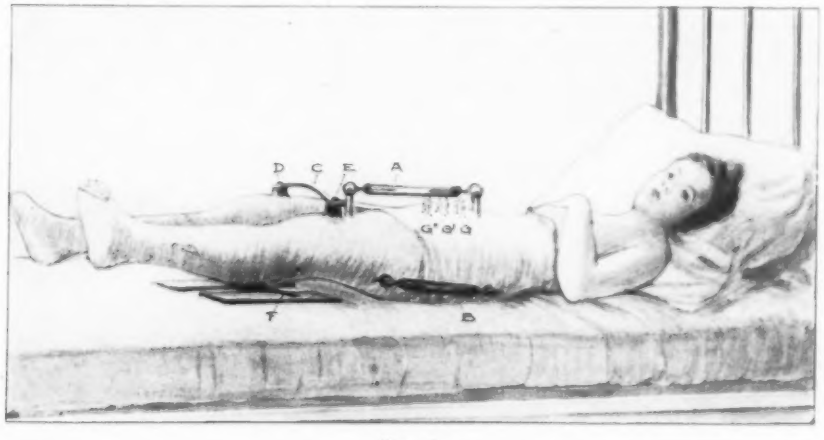

FIG. 1

Showing application of the turnbuckle cast.

FIG. 2
Showing position of the head of the femur before applying traction.

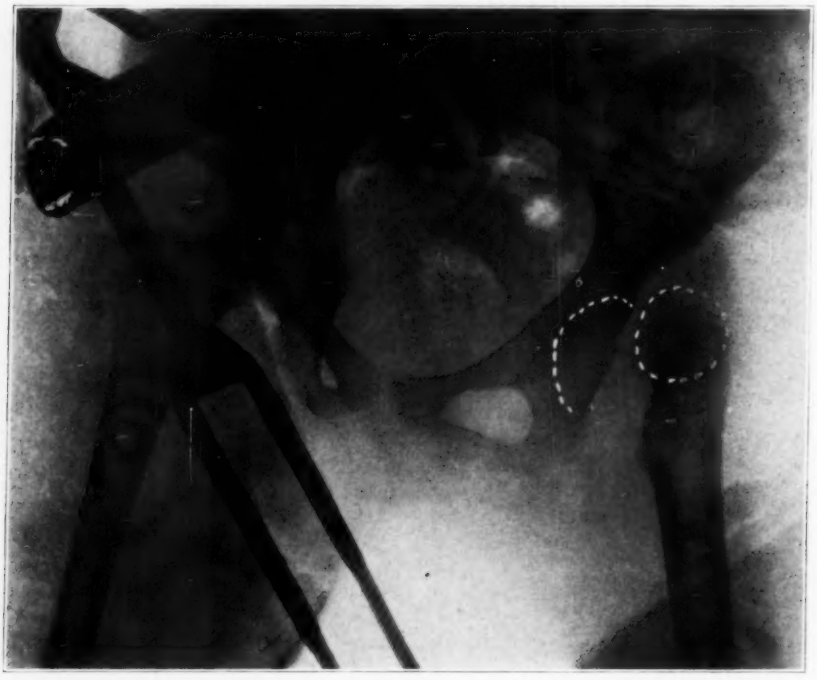

FIG. 3
After traction had been applied for three weeks.

FIG. 4

Same case, illustrating the postoperative result of the shelf operation. Shelf (*A*) has been turned down over the head of the femur. The wedge of bone (*B*) has been placed between the ilium and the shelf of bone.

nates the friction of the bed clothing and has proved to be a distinct asset. When the cast is completed, the thigh portion on the side of the involved hip is cut through at the level of the hip joint. By means of this construction it is possible to exert traction in a uniform plane and, at the same time, to maintain the corrective position of the extremity.

In a great many cases the maximum amount of traction obtainable has stopped just short of a complete reduction, but only because of the patient's inability to stand further leverage. The length of time required to accomplish the maximum amount of extension of the extremities varies from two to six months. It must be stated here that, in almost all of our cases of dislocation, we have found it advisable to follow the traction treatment with a shelf operation.

The advantage of pulling the head of the femur down before attempting to construct an acetabulum is that the leg, shortened as the result of the dislocation at the hip, is thereby lengthened and a new acetabulum may be more easily and satisfactorily constructed in that part of the ilium where the bone is normally thicker.

The authors are uncertain whether or not there is an increased tendency toward limitation of motion in the reconstructed hip because of secondary contraction of the soft tissue which has been stretched during the preceding period of traction. To lessen this possibility it is their cus-

tom to maintain the traction for a longer period than is really necessary to draw the femur down, in order to overstretch the resistant soft tissues as much as possible.

During the course of the stretching treatment it is usually necessary to change the cast two or three times, but the attachment point of one end of the two turnbuckles may be advanced two or three times (G to G' to G'') before changing the entire cast. We have used this type of cast for stretching congenitally dislocated hips in twelve cases, and in each case it has been found to be of distinct advantage.

Illustrations of one case showing the progress of a typically high dislocated hip together with the end result following a shelf operation are included.

This patient, E. P., a girl seventeen years of age, came for advice on account of a marked limping and pain on walking. She had a typical congenital dislocation of the left hip, first recognized when she began to walk, and for which she had had no treatment of any kind.

A turnbuckle cast was applied and worn for three weeks. By that time the patient's toleration of the traction was exhausted and the shelf operation was advised. Following the operation a cast for immobilization was applied. Her convalescence was uneventful.

ARTHRITIS: TREATMENT WITH SULPHUR BY INTRAVENOUS AND INTRAMUSCULAR INJECTION

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During a study of cases of arthritis observed in the Out-Patient Department of Providence Hospital, the cystine content of the finger nails in many cases was found to be below normal [1]. This finding suggested the treatment of these cases with some form of sulphur.

Seven cases were selected to receive such treatment. The diagnosis was made from the history of repeated attacks, the presence of pain, swelling and tenderness in the joint, rigidity of the muscles about the joint, deformity and limitation of motion, and roentgenographic changes characteristic of arthritis. In every instance there was definite evidence that an inflammatory reaction had taken place within the joint. The criteria for this impression were redness and swelling in the joint, excruciating pain on active and passive motion, and a high sedimentation reaction [2] in the absence of any other known cause.

In five cases, bony changes were present, but, as the predominant lesion seemed to be proliferative[3], these cases were selected for treatment.

Six of the patients had received other forms of treatment prior to the institution of sulphur therapy, without any apparent benefit. During the period in which sulphur was being administered, no other form of therapy was used. The injections were given, either intravenously or intramuscularly, in the form of Sulfur-Diasporal at weekly or biweekly intervals. The amount of each injection was approximately two cubic centimeters.

The cystine content of the finger nails was determined by Sullivan [1] and the results, as expressed in Table I, indicate the percentage of the substance in the material examined. The sedimentation reaction was determined by the Cutler method [4] and the readings were observed at the end of one hour only, as this was found to be sufficient [2].

Two types of improvement were noted: a marked improvement consisted of cessation of pain and tenderness, disappearance of the muscular rigidity and swelling, and restoration of mobility to the point of expectancy,—that is, allowances were made for the degree of limitation of motion; a fair improvement was manifested by absence of pain and tenderness and either diminution or disappearance of one or more of the other symptoms or signs. Improvement was not observed in any of the patients until after the fifth injection. The most marked reactions occurred in two of the four patients who had received twenty injections. The exception to this was the case of J. F. G., but no attempt can be made at this time to explain why she did not receive a more marked reaction. The same may be said concerning the case of G. G. The case of N. F. prob-

TABLE I

STUDY OF THE CYSTINE CONTENT OF THE FINGER NAILS BEFORE AND AFTER TREATMENT WITH "SULFUR-DIASPORAL"

Patient	Cystine Content of Nails		Number of Treatments		Clinical Improvement
	Before (*per cent.*)	After (*per cent.*)	Muscle	Vein	
B. C.	8.10	11.84	10	10	Marked
Mrs. D.	9.15	12.48	20	0	Marked
M. A.	7.95	9.17	12	0	Fair
G. G.	11.01	11.24	10	0	None
Miss H.	9.75	10.52	0	20	Fair
J. F. G.	7.84	11.10	0	20	Fair
N. F.	9.35	9.88	0	6	Fair

ably should not be included in this group because the injections were given at such unsatisfactory intervals that no beneficial result should be expected.

No febrile reaction was noted following an injection in any case. Furthermore, there were no untoward results, except in the case of J. F. G. who had a slight sloughing of the tissues, following the extravasation of the solution during the administration of an injection.

CASE REPORTS

CASE 1. B. C., a white male, aged nineteen, complained of intermittent pain and swelling of three years' duration in all of his joints. He had received treatment in the form of tonsillectomy, dietotherapy, colonic irrigations, and an autogenous vaccine, with no apparent benefit.

At examination, the predominant symptom was rigidity of the back, associated with pain. There was a muscular contracture of the left hand with Haygarth's nodes in all of the finger joints. The spinal muscles were rigid and this condition was associated with tenderness over the entire spinal column. Motion in the thoracic and lumbar portions was completely absent. The left knee was swollen and painful and tender on passive motion. Motion in this joint was limited to twenty degrees. The inguinal and cervical glands were palpable.

Roentgenographic examination revealed considerable bony intervertebral changes in the lumbar spine, with narrowing of the joint spaces and marked changes of the same nature in the hips and knees.

The sedimentation reaction was 30, and the cystine content of the finger nails was 8.10 per cent.

At three-day intervals, the patient was given ten intramuscular injections of Sulfur-Diasporal, followed by ten intravenous injections. After the twentieth injection, he was entirely symptom-free. The pain, swelling, and tenderness in the joints had disappeared. There was no rigidity of the muscles and no limitation of motion. The cystine content of the finger nails was 11.84 per cent. and treatment was then discontinued.

CASE 2. Mrs. D., a white female, aged forty-eight, complained of joint pains and marked limitation of locomotion for over a period of six years. The limitation of motion was confined mainly to the lower extremities and she was unable to move about without assistance. She could walk up steps only with a great deal of difficulty. The pain in the

joints was constant and was associated with swelling. Dietotherapy, colonic irrigations, and the removal of foci of infection produced no beneficial results.

Examination revealed contractures and deformity of both hands and wrists; Haygarth's nodes in all of the finger joints; redness and swelling of the dorsal surfaces of both hands and wrists; ankylosis of the left elbow joint which was fixed at thirty degrees; a deformity of the left knee, the motion of which was limited to within fifteen degrees of full extension, with pain and swelling; a limitation of twenty degrees of full extension in the right knee joint; and pain, swelling, and tenderness in both ankle joints.

Roentgenographic examination revealed bony changes in both wrists and the left elbow joint, with evidence of proliferative changes in the elbow joint. There were also bony changes in the knee joints, with narrowing of the joint spaces.

The sedimentation reaction was 25, and the cystine content of the finger nails was 9.15 per cent.

Twenty intramuscular injections of Sulfur-Diasporal were given at biweekly intervals. At the conclusion of the treatment, the patient could travel about unassisted. She was able to ascend stairs. The pain, swelling, and tenderness in all of the joints had disappeared. There was no rigidity of the muscles. The left knee could be placed in full extension and the motion of the right knee joint was limited to within only ten degrees of full extension. The ankylotic deformity of the wrists and the left elbow was not affected, but the pain and swelling had subsided. The cystine content of the finger nails was 12.48 per cent.

CASE 3. M. A., a colored female, aged twenty-three, complained of pain in her hip, knee, and shoulder joints, associated with some stiffness in the right leg. This condition had been present at varying intervals for about one year, but had been constant for two months. Salicylates, colonic irrigations, and a high vitamin, low caloric diet produced no relief. The pain and rigidity had become more intense and the patient had found it necessary to discontinue her work as a housemaid and to spend most of her time in bed.

The patient was well nourished and well developed. Both knees, the right hip, and the right shoulder were painful on both active and passive motion, and there was a moderate degree of swelling in and about both knee joints. There was a spindle-shaped deformity of most of the joints of the fingers, but this was not of sufficient degree to produce a limitation of motion.

No pathology could be found in the joints on roentgenographic examination.

The sedimentation reaction was 27, and the cystine content of the finger nails was 7.95 per cent.

Twelve intramuscular injections of Sulfur-Diasporal were administered at weekly intervals. At the end of this period the cystine content of the finger nails was 9.17 per cent. The swelling about the knee joints had disappeared and there was some diminution in the extent of the rigidity, but there was still a great deal of pain elicited on both active and passive motion. The patient discontinued treatment voluntarily.

CASE 4. G. G., a white male, aged sixty-five, complained of pain and limitation of motion in both shoulders and both elbows. The condition had been in evidence for about one month. It was gradual in onset and had become progressively worse. It was not associated with swelling about the joints and there was no previous history of joint disease.

The patient was poorly nourished, but well developed. There was a limitation of extension of thirty degrees in the right elbow. Pain was elicited on passive motion of this joint, but there was no swelling. There was tenderness over the lower cervical and the upper thoracic vertebrae and rigidity of the posterior cervical muscles. Both shoulders were tender and painful on both active and passive motion, but there was no limitation of motion in either.

Roentgenographic examination revealed bony changes in the right elbow joint, with a small amount of new bone formation on the tip of the coronoid process of the ulna.

There was also a narrowing of the intervertebral spaces of the cervical and thoracic vertebrae and some lipping of the bodies.

The sedimentation reaction was 20, and the cystine content of the finger nails was 11.01 per cent.

The patient was given ten intramuscular injections of Sulfur-Diasporal over a period of ten weeks; at the end of this period, the cystine content of the finger nails was 11.24 per cent. There was no noticeable change in his condition, the amount of pain, rigidity, and limitation of motion was the same as at the first visit, and the patient refused further treatment.

CASE 5. Miss H., a white female, aged thirty-two, complained of pain and stiffness of seven years' duration in both hips, the entire spinal column, and both wrists. The pains were constant and for about three months prior to examination she had been confined to her bed. Various methods of therapy had been tried, with no apparent benefit. Her condition seemed to be becoming progressively worse.

Examination showed absolute immobility of the spinal column, associated with rigidity of the entire group of spinal muscles. There was slight immobility of the right hip joint, evidently due to the rigidity of the muscles and to the pain which was produced by motion. The right knee was limited in motion to within ten degrees of full extension; there was rigidity of the muscles, redness and swelling about the joint, and pain on passive motion. Both ankles were tender, painful, and swollen. There was complete limitation of motion in both wrists, and Haygarth's nodes were present in the finger joints of both hands. The patient's ability to move about was greatly limited, due to the pain and the rigidity.

Roentgenographic examination revealed bony changes in both wrist joints, manifested mainly by a haziness in the outline of the bony structures. The vertebrae showed rarefaction of the bodies, with a narrowing of the intervertebral spaces. The hip joints were negative, but there was rarefaction of the proximal end of the right tibia, with spur formation and some evidences of cartilaginous changes.

The sedimentation reaction was 34, and the cystine content of the finger nails was 9.75 per cent.

Twenty intramuscular injections of Sulfur-Diasporal were administered at weekly intervals. At the conclusion of the treatment, the patient was able to sit up in a chair during the entire day. The tenderness in the ankles had disappeared, as well as the inflammatory reaction about the knee joint. There was no rigidity of the muscles of the right hip, and the patient was able to move about the house unassisted and could walk up and down stairs with assistance. The cystine content of the finger nails was 10.52.

CASE 6. J. F. G., a white female, aged fifty-three, complained of joint pains which had been in evidence for a period of six years. This condition had become progressively worse, in spite of the fact that she had tried numerous methods of treatment.

The right elbow was so rigid that the joint was fixed at twenty degrees from full extension. Both wrists were rigid and there was swelling, redness, and pain about these joints. The joints of the fingers of both hands were deformed by the presence of Haygarth's nodes. The muscles of the lumbar and thoracic spine were rigid, and there was tenderness over the entire spinal column. Both ankles were rigid and there was redness, swelling, and pain about the right ankle. There was redness, swelling, and rigidity of the muscles about the left knee, and active and passive motion of this joint was associated with excruciating pain.

Roentgenographic examination disclosed new bone formation, with marked evidence of periosteal changes. The bones of the elbow joint showed evidences of spur formation and rarefaction. There was narrowing of the intervertebral spaces of the thoracic and lumbar spine, with marked lipping of the bodies of the vertebrae. The left knee presented a marked lipping of the tibia, with spur formation and some evidences of cartilaginous changes.

The sedimentation reaction was 38, and the cystine content of the finger nails was 7.84 per cent.

Twenty intravenous injections of Sulfur-Diasporal were administered, following which the cystine content of the finger nails was 11.10 per cent. The swelling about the joints had disappeared, as well as the redness and rigidity of the muscles. Although pain was still present, it did not seem to be as severe. Otherwise, no improvement was noted in the patient's condition.

CASE 7. N. F., a white female, aged fifty-two, complained of pain in her joints, especially in the knees. This condition had been present for over a period of six years and the patient stated that all of her joints had been involved at one time or another.

The joints of both hands and wrists were swollen and painful, with limitation of motion, apparently due to the pain and the muscular rigidity. The left knee was swollen and painful on both active and passive motion. There was also some tenderness and swelling of the right ankle. There was pain, swelling, and rigidity of the muscles about the right knee. The patient's teeth and tonsils had been removed, but her condition had become progressively worse. Motion in the right knee was limited to within ten degrees of complete extension. No other evidences of ankylosis were present.

Roentgenographic examination revealed no evidences of arthritic changes in the wrists, left knee, or ankles. There was some lipping of the right tibia, with some cartilaginous changes.

The cystine content of the finger nails was 9.35 per cent., and the sedimentation reaction was 55.

The patient received six injections of Sulfur-Diasporal intravenously over a period of two months. At the end of that time the cystine content of the finger nails was 9.88 per cent. The swelling in both knees, the pain in all of the joints, and the rigidity had abated to some extent, and she was able to perform her duties with less difficulty.

COMMENT

All of the seven cases observed were definitely inflammatory in nature. This condition was coexistent with a consistent diminution in the cystine content of the finger nails, which gave rise to the belief that this phenomenon was associated with a disturbance in the sulphur metabolism [1]. Therefore, sulphur therapy was begun. In all but one of these cases some degree of clinical improvement was noted. In all of the cases, the cystine content of the finger nails increased after treatment.

These results suggest that sulphur therapy may be of benefit in certain cases of arthritis. Although the number of cases mentioned here is small, there is evidence of a consistent increase in the cystine content of the finger nails. This increase is proportional to the number of injections and is associated with clinical improvement.

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THE OPERATIVE CORRECTION OF EXTREME FLEXION CONTRACTION OF THE GREAT TOE

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Structural changes and the deviation from the normal in the foot are often dependent upon muscular imbalance, which leads to deformity and contraction of the toes with subsequent faulty weight-bearing. This type of foot (Fig. 1) is characterized by a fairly high arch with loss of normal elasticity, with or without a slight equinus due to contraction of the calf muscle. The cause may be an inherited peculiarity, but is more frequently the remnant of some affectation of the cerebrospinal nervous system. A mild attack of poliomyelitis, some infectious disease of childhood, or congenital lues may be the factor in the production of such conditions.

When the deformity becomes extreme, the weight is thrown on the first metatarsal head, and the great toe soon loses the grasping power in walking. Painful callosities develop on the dorsum of all the toes, most severely on the first toe. Corresponding areas are found under the head of the first metatarsal bone. Inflammation and infection are often present. The accepted methods of treatment may be conservative (stretchings, tenotomies, and foot plates), or directed to removal of the deforming influences by transplanting the extensor tendons of the foot into the metatarsal heads with arthrodesis of the interphalangeal joints.

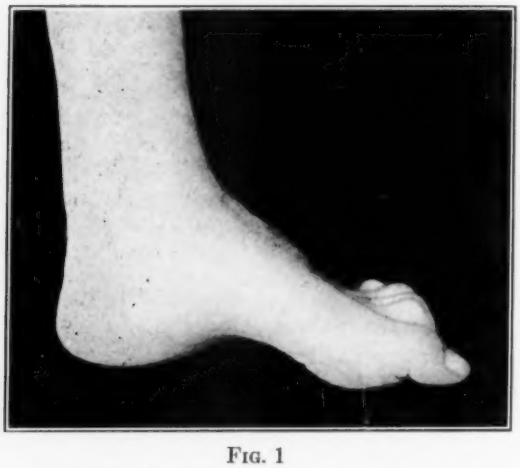

FIG. 1

Photograph showing the high arch, marked contraction of toes, and how weight is borne on the head of the first metatarsal bone. None of the toes grasp the ground. Female, aged twenty-five; complaint, painful first toes and callosities; congenital.

When the extensor hallucis longus is transplanted to the metatarsal head, the elevation in the metatarsal bone is secured, and normal grasping power of the great toe returns, but dorsiflexion is lost; this condition makes walking in the bare feet difficult, because of the dropped toe. By transplanting the extensor tendon of the fifth toe to the base of the first phalangeal joint, this difficulty can be obviated and a very satisfactory

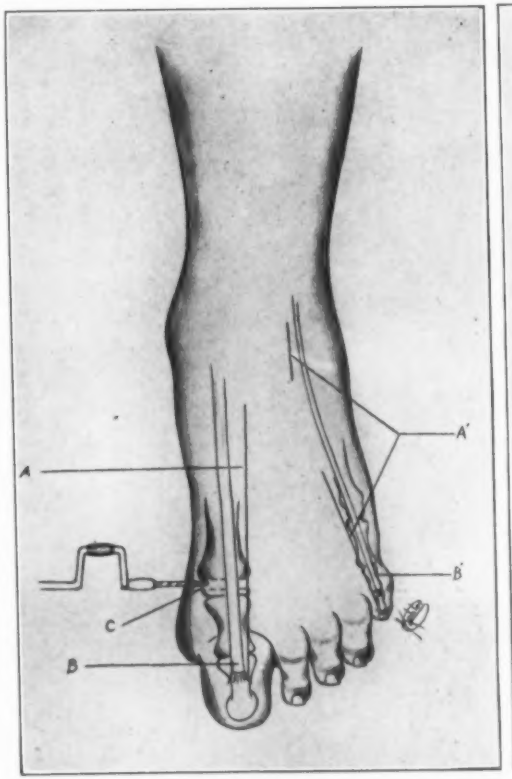

FIG. 2-A

Drawing showing lines of incision *A* and *A'*. *B* and *B'* represent points at which tendons are divided. *C* is site of drill hole in metatarsal head.

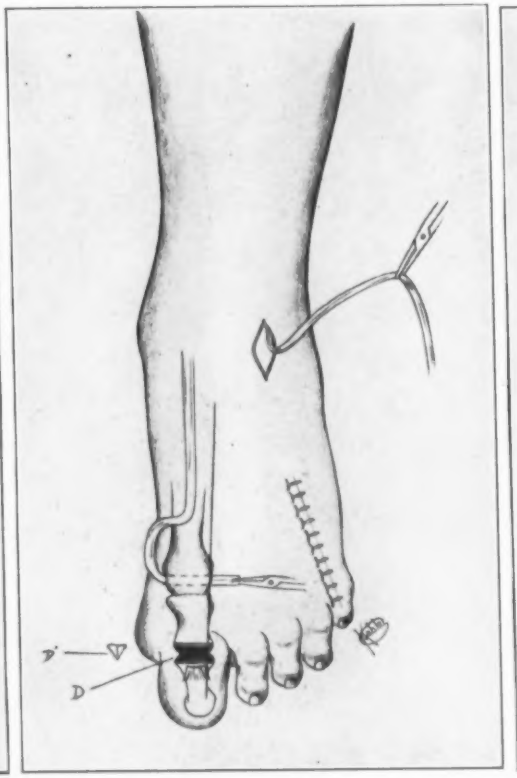

FIG. 2-B

Drawing showing contracted first toe. *D* and *D'* represent wedge resection of the interphalangeal joint.

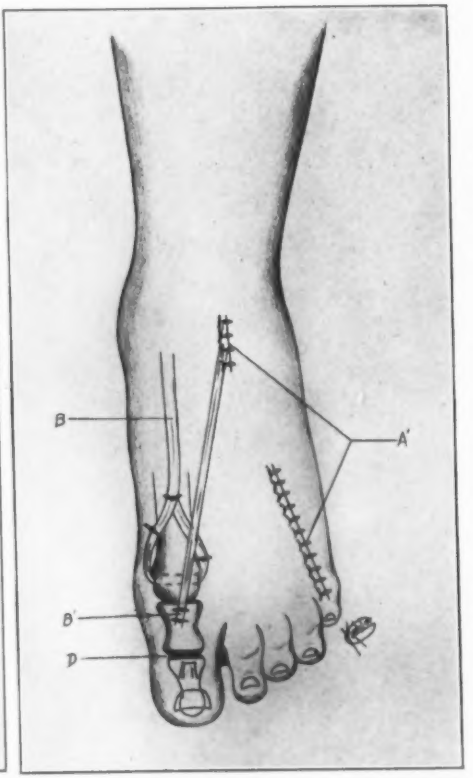

FIG. 2-C

Drawing showing operation completed, and transplanted tendons *B* and *B'* *in situ*. Deformity has been corrected.

FIG. 3

Photographs showing attitude in which the foot is dressed in plaster. Note elevation of metatarsal heads and plantarflexed toes.

foot secured. The sesamoid bone of the great toe should be removed in extreme cases, as often it is found to be distorted or inflamed because of the persistent trauma to the surrounding area.

OPERATIVE PROCEDURE

The foot is prepared in the usual manner and a tourniquet is applied. A long incision (Fig. 2-A) is made over the extensor hallucis longus tendon, which is exposed, and its attachment divided as far distally as possible. A similar incision is made over the extensor tendon of the first toe with division of its attachment. The tendon is freed and drawn out through a small incision below the annular ligament of the ankle joint. The interphalangeal joint of the first toe is excised in a wedge-shaped fashion and the deformity of the toe is corrected. A large drill hole is made through the metatarsal head about one-quarter of an inch from its articular surface. The sesamoid bone is inspected and removed if found diseased;

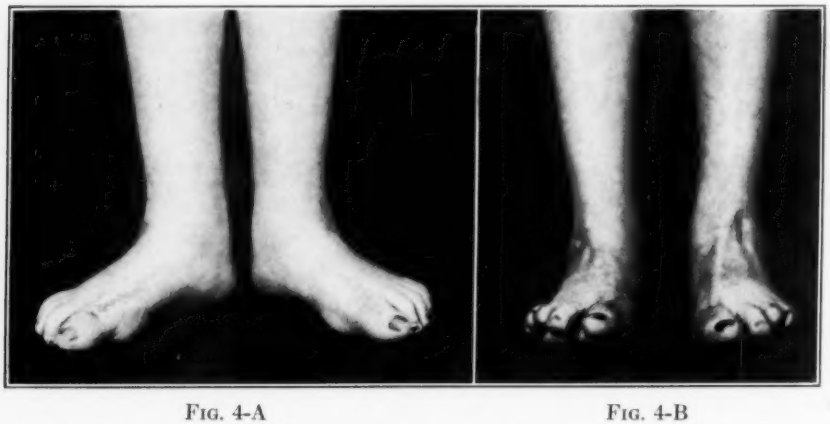

FIG. 4-A

Photograph of feet of same patient [(Fig. 1),] after correction. The first toe grasps the ground at its end.

FIG. 4-B

Same as Fig. 4-A, showing amount of dorsiflexion present. The transplanted tendon is seen functioning.

the extensor hallucis longus tendon is then passed through the drill hole (Fig. 2-B) and sutured on itself, after a satisfactory elevation of the metatarsal head has been secured. The tendon of the fifth toe is drawn across the foot and placed in the base of the first phalanx (Fig. 2-C). Subcutaneous tenotomy of the second, third, and fourth extensor tendons is performed, and the toes are thoroughly stretched into plantar flexion. This new position is held by a trained assistant, while the wounds are closed and a plaster-of-Paris dressing is applied with the foot at a right angle and the toes in the corrected attitude (Fig. 3).

FIG. 5-A

Feet of child, aged eight years; etiology, spastic paraplegia, congenital; complaint, marked callosities and pain on walking; unable to wear shoes.

FIG. 5-B

Same as Fig. 5-A, after correction. The first toe is completely straight and grasps the ground.

AFTER-CARE

At the end of three weeks the plaster is removed, wounds are dressed, and sutures are removed. After the utmost correction has been secured, by raising the metatarsal arch and by plantar flexion, a walking plaster is applied. Walking is encouraged in the new attitude. Between the sixth and eighth weeks, depending on the degree of deformity, the plaster is removed, and a well fitting shoe is applied in which a metatarsal bar is inserted. Physiotherapy is instituted, and walking is encouraged in the new attitude. Because of the long immobilization and the removal of all the pressure areas, all callosities have disappeared and the patient is quite comfortable.

COMMENT

Twelve individuals have been operated upon (eight bilateral, four unilateral). The ages ranged from six years to thirty-five years. The sesamoid bone was removed in five patients, all of whom were past twenty-five years of age. The range of dorsiflexion of the great toe which was secured by the new procedure was estimated as about fifty per cent. of normal. In one case it was necessary, because of the faulty attitude, to revise the arthrodesis of the interphalangeal joint of the great toe. The improvement in gait was most noticeable in each case, and the relief of pain was exceedingly satisfactory.

SUMMARY

The accepted treatment of flexion contraction of the toes with its etiology is reviewed. Special emphasis is placed upon the importance of the deformity of the first toe and its sesamoid bone in causing the great disability. The transplantation of the extensor tendon of the fifth toe to the base of the first phalangeal bone is added to the routine procedure in order to secure dorsiflexion of the great toe with a more accurately balanced musculature.

A LARGE BILOCULAR SYNOVIAL BURSA IN A PLANTARIS OF MAN

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From the Department of Anatomy, Stanford University

The body of a male laborer eighty-four years old, dead of uraemia, contained the very unusual bursa shown *in situ* in Figure 1. It was located in the right plantaris and was so large that the shape of the muscle belly was greatly altered. The bursa was tensely filled and bilocular,

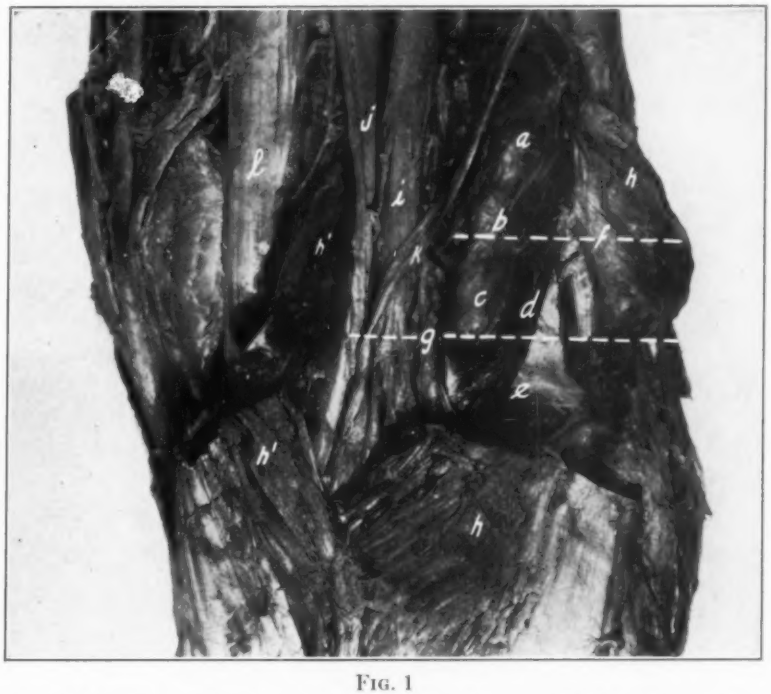

FIG. 1

The right popliteal and sural regions before the removal of the plantaris: *a* marks the smaller sac; *b*, the neck; *c*, the larger sac; and *d*, the group of muscle fasciculi that passed lateral to the bursa. The articular capsule of the knee joint over the lateral condyle can be seen at *e*. The location of the greatest prominence of the lateral condyle of the femur is indicated by the dotted line *f*. The position of the sulcus when the knee is flexed is marked by the dotted line *g*. The sectioned medial and lateral heads of the gastrocnemius are designated by *h'* and *h* respectively; *i* indicates the tibial nerve; *j*, the tendon of the semitendinosus; *k*, the anastomosing branch of the peroneal nerve; and *l*, the tendon of the semimembranosus.

with a larger distal portion (*c*) and a smaller proximal portion (*a*) (Fig. 4). A narrow neck (*b*) with a thick, dense, connective-tissue wall connected the two loculi, giving the bursa a rough hour-glass form, largely obscured by overlying muscle. Small groups of muscle fasciculi passed over the

larger sac to reach the tendon, and the connective tissue associated with these fasciculi blended with that of the bursal wall. A relatively large group of fasciculi passed lateral to the large sac and were not involved in its wall. The smaller sac and the narrow neck were hidden by portions of the belly of the muscle.

After the tendons had been removed from the two muscles shown in Figure 2, the muscles were weighed. The right belly, including the bursa and its contents, weighed 6.9 grams, but, without the bursal content, only 4.7 grams; and that of the left muscle weighed 2.2 grams. The belly of the right muscle was 10.3 centimeters in length and that of the left was 10.0 centimeters. The greater net weight of the right muscle was undoubtedly due mainly to the large, thick bursal wall, for the muscle was atrophic over the dorsal surface of the bursa. The greatest length of the bursa was 4.7 centimeters and the greatest diameter of the larger sac was 2.0 centimeters. The lumen of the neck was 2.2 millimeters in diameter.

FIG. 2

The two plantaris muscles. The lettering has the same significance as in Fig. 1.

The bursa had no communication with the knee joint and, although it was not observed until the plantaris was exposed, it no doubt was easily palpable in the cadaver and during life, through the overlying skin, fascia, and muscle. It was large enough so that it probably also affected the external appearance of the surface area. A careful examination of the skin immediately over the bursa revealed no trace of attrition; nor were any scars present. The fascia and joint capsule also were normal. A small sesamoid bone (0.5 centimeter by 0.5 centimeter) was contained in the capsular part of the tendon of the lateral head of the gastrocnemius, as is frequently the case.

It was located lateral to the plantaris, at approximately the level of the narrow portion of the bursa, and hence probably was not a factor in the production of the bursa.

A part of the bursal wall was examined microscopically and revealed the usual structure. The outer portion of the wall was formed by dense, regularly arranged, fibrous connective tissue and the collagenous fibers were, for the most part, arranged in the direction of the long axis of the muscle. The number of nuclei increased as the inner surface of the bursal wall was approached and, although the cells were fairly numerous, they did not suggest a specialized lining membrane. The connective tissue associated with the muscle fibers blended with that of the wall. Some small projections of connective tissue also extended into the bursa.

When the tense bursa was opened, 2.25 cubic centimeters of thick but translucent, very viscous, fluid were removed. Smears were made from this fluid and stained with gentian violet and Wright's blood stain. Some cellular débris was found, but, for the most part, the smear appeared merely as if a heavy coating of albumen had been stained. The interior of the larger sac was quite regular, but that of the smaller was very irregular, due to numerous thin septa which subdivided it into many loculi. Coarser septa were present in the proximal two-thirds of the narrow neck, but these were not wide enough to occlude the lumen. The walls of the loculi, like those of the larger sac, were smooth.

Hammarsten, in 1914, described synovia as "an alkaline, sticky, fibrous, yellowish fluid which is cloudy from the presence of cell nuclei and the remains of destroyed cells, but it is also sometimes clear". He added that "the fluid in the bursae mucosae . . . is similar to synovia from a qualitative standpoint". It is probable that the synovia found in joints differs from that found in bursae only in the presence of cartilaginous débris and the products of hyoid cartilage in the former. The marked viscidity of the contents of this bursa was probably due to two factors. The fluid may have been concentrated somewhat by post-mortem absorption, but there was little dehydration, for the bursal wall was tense. The body had been embalmed and this probably caused a coagulation of the proteins and a thickening of the fluid.

No parasitic cysts were found in this body and the bursa was plainly not inflammatory in origin. The walls were quite smooth and there can be little doubt that this was a very unusual mucous bursa. The condition that led to its formation probably was long continued use under special conditions. Any prolonged occupation or posture in which the right leg, flexed at the knee, rested on some projection that caused pressure upon this muscle during movement, could have resulted in the formation of a bursa. Partly intramuscular bursae are sometimes found in the caudal (inferior) portions of the glutei maximi. Pressure alone would not lead to the formation of a bursa, since, to produce the requisite attrition in acquired bursae, some movement would be necessary.

Most of the muscular part of the plantaris probably suffered from

FIG. 3

The opened intra-aponeurotic bursa: *a*, near the fracture of the eighth right costal cartilage; *b*, large thickened trabeculae; and *c*, smaller trabecula almost at right angles to *b*.

pressure atrophy, due to the contained bursa, but the proximal portion at the level of the greatest prominence of the lateral condyle of the femur suffered more because of the greater intensity of the pressure here. The first part of the bursa to form was probably the small proximal sac which was located at this level. This sac probably extended in the direction of least resistance,—that of the long axis of the muscle, but expanded little laterally because of the pressure exerted by the contracting muscle fibers. The extension of the bursa distally reached the region of the musculotendinous junction where there were relatively fewer muscle fibers and more connective tissue. Here it expanded to form the large distal sac. Some support is given to this supposition by the fact that the large sac had involved comparatively few muscle fasciculi. The close adherence of the plantaris to the capsule of the knee joint would account for the fact that no bursa was formed between these two structures.

Dr. Meyer called the author's attention to a somewhat similar instance of the development of an aberrant bursa noted in this laboratory seven years ago. In this case, a large bursa, approximately 3.5 centi-

meters by 4 centimeters, involved the aponeurosis of the right external oblique muscle on the body of a male (Fig. 3). At a considerable time before death, the right eighth costal cartilage had been fractured and over this old fracture, and adjacent to it, a large trabeculated sac had developed. The fractured ends of the cartilage had not united, but had become rounded through wear and resorption. Large, thick trabeculae passed through the bursa, for the most part in a direction parallel to the eighth rib, and much smaller trabeculae ran for short distances at right angles to the larger ones.

This bursa, like the one previously described, probably was produced by movement against some external object, such as a cartridge belt, causing long continued friction between the fractured cartilage, the aponeurosis, and the underlying ribs. The trabeculae were remnants of the originally continuous aponeurosis of the external oblique muscle which had become thickened in response to the attrition. In this case, friction and movement were not intense enough to cause the presence of an abnormal amount of fluid at the time of death.

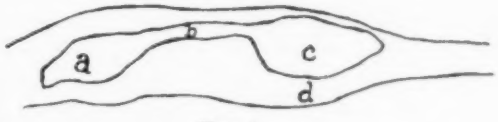

FIG. 4

Diagram made from a longitudinal section of the right plantaris, showing the relative size of the bursa and the belly of the muscle. The lettering has the same significance as in Fig. 1.

Power, in 1885, described the first of a series of apparently similar instances of aberrant synovial cysts under the general heading of intermuscular synovial cysts. However, these cases were quite different from the one here described, since all but one of these cysts communicated with joint cavities and all of them were intermuscular rather than intramuscular. The explanation was that they were herniated articular synovial membranes or so called ganglia. Moreover, most of them were infected and the infection had usually destroyed most of the articulation.

Meyer, in 1915, briefly described a case of bilateral intragluteal bursae which were partly contained in the subcutaneous fat. He stated, however, that "these bursae were in no sense comparable in location to the ordinary subcutaneous bursae and could with entire justice be designated as intramuscular". These bursae were thin-walled, trabeculated, and empty.

In 1929, Stibbe reported the finding of a bursa in the subscapularis muscle. It was imbedded in the muscular part of the subscapularis near the tendon of insertion and the muscle fibers could "readily and completely be pushed aside from it without any dissection". He compared the fluid contained to raw white of egg and stated that the "cavity [was] lined up by an imperfect, small-celled endothelium", but he made no attempt to explain the condition or the presence of the endothelium.

This report was made at the suggestion of Dr. Meyer because of the great rarity of the condition, especially in such small muscles as the plantaris, and because of the ab-

sence of such cases in the literature consulted. The author wishes to express his appreciation to Dr. Meyer for the privilege of making the report and for his suggestions in regard to it.

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A NEW TREATMENT FOR DELAYED UNION OR NON-UNION IN FRACTURES

BY RALPH M. CARTER, M.D., F.A.C.S., GREEN BAY, WISCONSIN

Not infrequently cases of fracture are seen in which the healing time is greatly prolonged, far exceeding any period which may be considered as within the normal limits, or in which non-union may occur. Omitting entirely a discussion of the underlying causes of such delayed or absent union, it is the author's purpose in this paper to describe a simple method of treatment which he has found effective in certain of these cases. So far as he has been able to ascertain, the procedure was first proposed by Beck[1], of Kiel, in 1929. Following the publication of Beck's paper, the method was utilized and strongly recommended by Böhler[2,3], but apparently it is but little known in this country, and has not been widely adopted. Bozsan[4,5] has recently described a treatment for fractures of the neck of the femur and Legg-Calvé-Perthes disease in which the same principle is utilized, but the author has found no mention in recent American literature of its having been used in cases of delayed union or non-union.

The procedure is very simple and consists merely of boring a number of small holes through the fragment ends, across the line of fracture. This gives rise to a certain amount of hemorrhage, allows the penetration of new blood vessels, and furnishes fresh bone pulp, thus creating a stimulus to new bone formation.

All the instruments necessary are shown in Figure 1,—a carpenter's

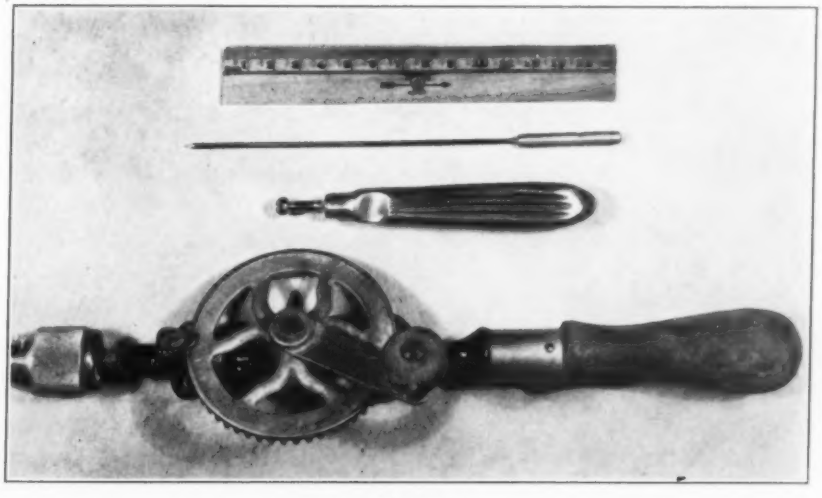

FIG. 1

Instruments used in operation.

hand-drill holder, a wire drill, one and five-tenths millimeters to two millimeters in diameter, and a small instrument for holding the point of the drill steady. A spiral drill is not satisfactory, because it has a tendency to draw the bone pulp out of the wound.

In the author's first case, half of a Kirschner wire of the largest size was used for a drill, but it was found to be too flexible for satisfactory work. Also, due to the fact that the direction of drilling was at an obtuse angle to the longitudinal axis of the bone, the point of the drill displayed a marked tendency to slip and to jump out of place. Therefore, the writer had a drill made slightly larger than the Kirschner wire, and tempered to as much rigidity as was consistent with strength. A small instrument for holding the drill point steady was also devised by the author. This consists of a metal handle with a hole through its tip slightly larger than the diameter of the drill. At first, an electric motor for drilling was used, but it was found that the excessive speed caused some burning of the skin; consequently, the motor was abandoned in favor of the hand-drill.

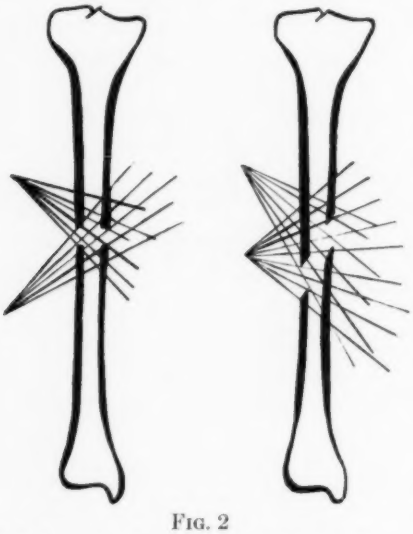

FIG. 2

Schematic drawing showing the direction of the drill holes.

The operation itself is extremely simple. It is performed under nitrous-oxide-oxygen anaesthesia, using the strictest aseptic technique. The point of the drill is slipped through the hole in the small stabilizing instrument, and is then pushed through the skin at a point either distal or proximal to the fracture line, until it comes into contact with the bone. By pressing the stabilizer firmly against the skin, the assistant steadies the point of the drill, which is now made to penetrate the bone in a diagonal direction, so as to cross the fracture line and to enter the other fragment. The drill is then withdrawn to the periphery of the bone, *but not outside the skin*, and the drilling is repeated in a slightly different direction. In this way, through a single skin puncture, six to eight, and sometimes more, holes can be drilled in a small bone, and ten or twelve holes in a larger bone. The more holes which can be drilled the better. The drill is withdrawn and the same procedure is repeated through a skin puncture on the opposite side of the fracture line. If necessary, one or two additional punctures may also be made. The direction of the drill holes is shown diagrammatically in Figure 2. The operation is completed by the application of an unpadded cast,—ambulatory if the fracture involves the leg. A roentgenogram taken four to six weeks later will usually show definite callus formation.

So far, this method has been used in five cases,—one of fracture of the shaft of the femur, two of fracture of the tibia, and two of fracture of the forearm.

Figure 3 shows a case of non-union of the ulna. The patient was injured on November 12, 1932. In April 1933, the radius was firmly united, but there was no union whatever between the ulnar fragments. On April 18, 1933, the fragments were drilled and a cast was applied. The cast was removed on June 20, 1933, when union was found to be firm.

The patient whose roentgenograms are shown in Figure 4 was injured on July 19, 1932. In November 1932 there was no attempt at union and

FIG. 3

Fracture of the ulna before and after drilling.

the bone was drilled on November 8, 1932. An ambulatory cast was applied. On December 27, the roentgenogram showed very satisfactory callus formation, and, early in February 1933, there was clinically firm union and the cast was discarded.

From his limited experience with this method, it is the author's opinion that, in those fracture cases with delayed union or non-union for which no cause can be found which would definitely indicate some other form of treatment, the simplicity and harmlessness of this procedure warrant giving it a trial before resorting to open operation. When the drilling is properly done, the risk of infection is negligible and prolonged hospital confinement is unnecessary. If this treatment is successful, roentgeno-

FIG. 4

Fracture of tibia. Reading from left to right, the first view shows the condition before drilling; the middle one shows the progress of callus formation, approximately seven weeks after treatment; and the last one shows the end result.

graphic evidence of callus formation will be seen in three to five weeks; if not, open operation can then be performed. The only contra-indication to the performance of the drilling is an open, infected fracture.

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CONGENITAL FUSION OF THE SPINE *

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Developmental anomalies of the skeletal system are not infrequently observed, and the vertebrae are probably involved more commonly than any other part. These anomalies are most often limited to the neural arch, and rarely involve the body proper. In the last few months we have observed four cases with changes in the vertebral body, such changes manifesting themselves in the form of a localized fusion of two or more vertebrae. This is not the first report of the anomaly, as a similar process has been observed by Steindler, Peabody, Pan, LeCocq, and others. The rarity of its occurrence, however, has prompted us to report these four cases.

REPORT OF CASES

CASE 1. A boy, fourteen years of age, was admitted to the Clinic April 13, 1934. He had been born at full term; delivery had been normal; and he had been normal at birth so far as his parents knew. His past history was entirely negative aside from the fact that, at the age of one year, his parents first had noticed kyphosis of the lower part of the back. The curve had increased slowly in severity as the child had grown. When he was eleven years of age he had begun to wear a back brace, but the curve had continued to increase in spite of the brace. Symptoms from this condition had not been noted at any time.

General examination revealed bilateral undescended testes but, except for the condition of the back, otherwise gave negative results. Examination of the back revealed marked kyphosis of the upper lumbar vertebrae with fixation of the spine in this region. Muscle spasm and tenderness were absent. A roentgenogram revealed marked kyphosis, and fusion of the anterior portion of the first, second, and third lumbar vertebrae (Fig. 1). The back brace was readjusted to fit the deformity.

CASE 2. A boy, fifteen years of age, came to the Clinic for examination February 17, 1934, because of progressive kyphosis of the lumbothoracic part of the spinal column. This deformity had been noticed for the first time about one and a half years previously, and it had slowly progressed. The patient never had had any symptoms referable to the back. There was no history of influenza, measles, typhoid fever, or of other infection.

Examination revealed kyphosis of the lower portion of the thoracic spine with fixation in this region. There was no evidence of any other anomaly and general examination otherwise gave entirely negative results. A roentgenogram revealed fusion of the anterior portions of the bodies of the ninth and tenth thoracic vertebrae (Fig. 2). The posterior half of the intervertebral disc and the nucleus pulposus were apparently normal. There was no bony overgrowth at the site of the fusion. The patient was fitted with a Taylor back brace and received instruction in hyperextension exercises.

CASE 3. A woman, thirty-four years of age, came to the Clinic January 10, 1934, with the complaint of bleeding from the vagina. In the course of examination it was

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learned that she had suffered from aching pain in the thoracic vertebrae for eight years; this pain had been present only when she had done heavy work and it had always disappeared with rest. The condition had been diagnosed previously as tuberculosis. However, the patient had never had any pain on stooping or from jarring; she had never had elevation of temperature in the afternoon; and her general health had always been excellent.

Examination of the back gave negative results except for indicating moderate low thoracic kyphosis and the absence of motion in this area. The pain, when present, was referred to the region immediately above the fixed portion of the spine. A roentgenogram revealed fusion of the ninth, tenth, eleventh, and twelfth thoracic vertebrae (Fig. 3). There was no progression in symptoms or in deformity; treatment, therefore, was not advised.

Case 4. A man, thirty-three years of age, was first admitted to the Clinic in 1926, complaining of pain at the level of the eleventh thoracic vertebra which had been present for fourteen years. This pain always had been aggravated by activity. He had not received previous treatment. His general health was very good. Examination revealed ankylosis of the twelfth thoracic and of the first, second, and third lumbar vertebrae. A diagnosis of old healed tuberculosis had been made.

In the spring of 1934, the patient returned to the Clinic for further observation. At

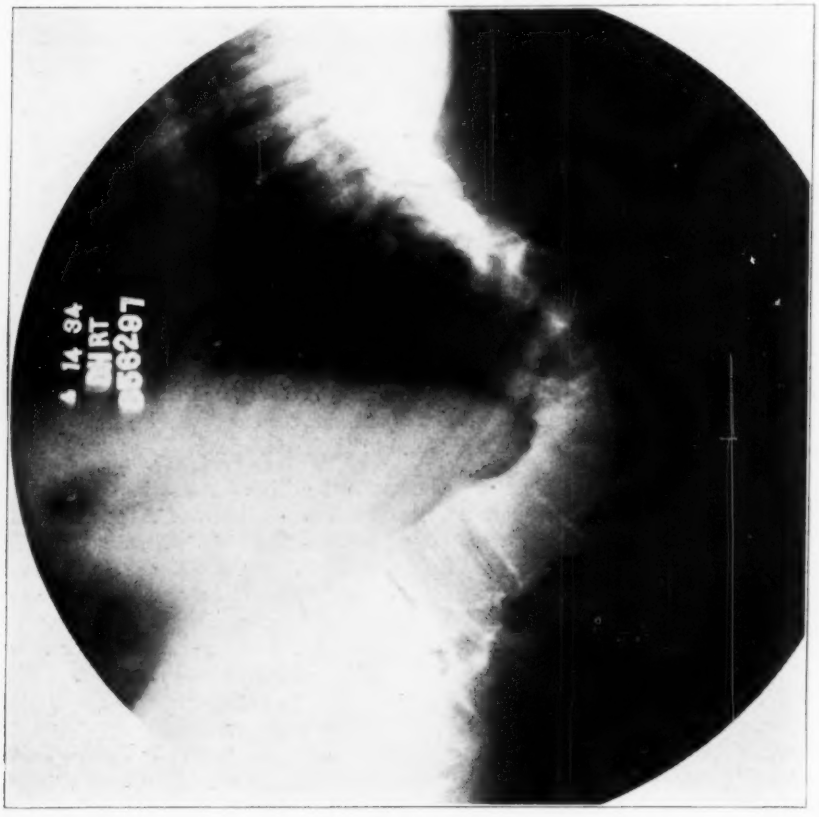

Fig. 1

Marked kyphosis, and fusion of the anterior portion of the first, second and third lumbar vertebrae.

this time his chief complaint was pain in the lumbosacral region. Examination revealed absence of motion in the lumbothoracic region and in the upper lumbar vertebrae. There was no tenderness or muscle spasm. On reviewing the roentgenograms it was noted that only the anterior halves of the vertebrae were fused (Fig. 4). There was no evidence of a healed abscess, nor was there any bone reaction at the site of the fusion. The patient's past history was investigated very carefully, but no history of any infection was obtained which could have produced such a lesion.

COMMENT

In reviewing the cases it will be seen that all of the patients were young at the onset of symptoms. Furthermore, the similarity in these cases is borne out both by the clinical and roentgenographic findings. In every case the chief complaint was painless kyphosis, whereas all other symptoms were localized, either to just above or just below the fused region, and were attributed to undue strain at these points. There were no findings to substantiate the presence of an inflammatory lesion, and in no case was there a history of tuberculosis, typhoid fever, measles, scarlet

FIG. 2

Fusion of the anterior portions of the bodies of the ninth and tenth thoracic vertebrae.

FIG. 3

Fusion of the ninth, tenth, eleventh, and twelfth thoracic vertebrae.

fever, or of any other infection that might have been an etiological factor. Roentgenograms revealed fusion of only the anterior halves of the vertebral bodies with rather marked localized kyphosis. The posterior half of the intervertebral discs and the nuclei pulposi were intact and apparently normal in all cases. There was no reaction around the fused area, either in the soft tissues to suggest a healed abscess, or in the bone to suggest an inflammatory process.

A comparison of the cases reported here with those previously reported by other authors revealed that the cases were similar in almost all respects. However, we were unable to find any notation by other authors

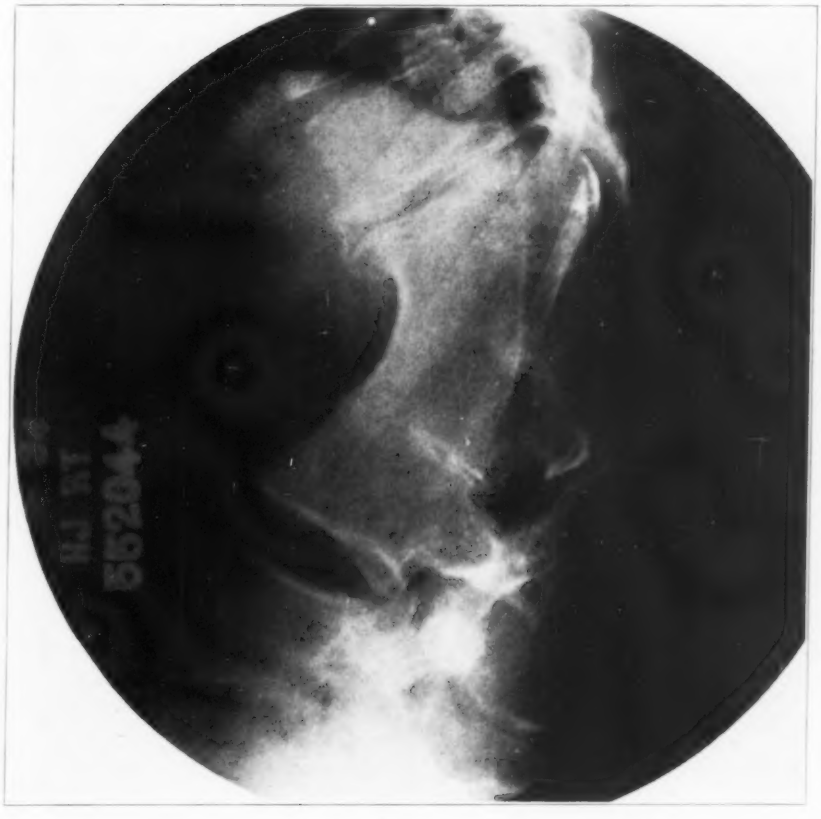

FIG. 4

Fusion of anterior halves of the twelfth thoracic, and first, second, and third lumbar vertebrae.

that the fusion was limited to the anterior half of the vertebral body. In the cases of Pan, fusion was limited to the cervical part of the spine and included the entire body and neural arch. In Peabody's case, there were several other developmental anomalies of the spine associated with the fusion. In one of our cases, bilateral undescended testes were associated with the anomaly in the spine, whereas in the other three cases the spinal fusion was the only abnormality to be found.

In searching for an explanation of the cause of the fusion, we were unable to find evidence of an inflammatory process of any type. The involvement of only the anterior half of the vertebral body strongly suggests a developmental abnormality. This would also account for the slowly progressive kyphosis, because the absence of the growth centers in the anterior half of the body results in a lack of growth in this portion, while the posterior half develops normally. The condition may have its origin in incomplete cleavage of the segmental scleromeres, with failure to differentiate that portion which forms the anterior half of the inter-

vertebral disc; thus the anterior half of the disc fails to form or, as Steindler suggested, the cause may be a localized arrest of growth at a very early developmental stage when the spinal column still forms an unsegmental cartilaginous rod. The condition may be classified in the group in which there is the Klippel-Feil syndrome and absence of the lumbosacral disc.

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THE CORRECTION OF KNEE-FLEXION DEFORMITY, AFTER POLIOMYELITIS, BY WEDGING PLASTERS

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Flexion deformity of the knee is a frequent result of poliomyelitis. The knee usually has a weak quadriceps extensor and is unstable, giving way on weight-bearing. Some degree of stability can be secured in a knee with a paralyzed quadriceps by maintaining that knee in recurvatum.

Little, Heather Bigg, Roberts, Young, Turner, L. D. Smith, J. P. Lord, Masland, Cravener, Kulowski, and Nutt have described methods of securing a back-knee, some of them requiring complicated apparatus. The literature, is, however, lacking in analyses of the reasons for failure to correct or to maintain correction of knee-flexion deformity by a closed method. That failures have occurred is indicated by the trend to operative procedures. These include the open release, as performed by Wilson, Lord, and Silver, and supracondylar femoral osteotomy. Fusion of the flail knee has been found necessary in many instances.

It is our purpose to analyze the reasons for success or failure in stretching knees, as well as the reasons for the resulting stability or instability of those knees.

We have studied 111 knees which were stretched to correct a flexion deformity following poliomyelitis, at the New York Orthopaedic Dispensary and Hospital in the years 1928 to 1931 inclusive.

The flexed knees occurred in eighty-six patients and in fifteen of them the deformity was bilateral. Ten knees had a second stretching. As considered in this report one case means one stretching and wedging treatment of one knee. The cases were followed for six months to five years (an average of two years) after the removal of plaster.

EXAMINATION BEFORE STRETCHING

The age at time of stretching ranged from three to twenty-three years. Forty-eight cases were in males and sixty-three in females. The duration of paralysis varied from two to twenty years; it was five to ten years in half the cases. The flexion deformity was five degrees in eleven cases, ten degrees in forty-eight, fifteen degrees in forty, twenty degrees in eight, and more than twenty degrees in four cases.

Knee stability is defined as follows:

A totally unstable knee, or one with "zero" stability, is one for which a long leg brace is required and on which weight-bearing is not even attempted without the brace.

A knee with "poor" stability requires the bracing support of the hand on the thigh in walking.

A "fairly" stable knee is one which does not give way when the patient walks across the examining room without supporting it, but which, according to the statement of the patient or his parents, gives way occasionally.

A knee with "good" stability does not give way.

The stability of the knee before stretching was recorded in 108 cases. Twelve were totally unstable, forty-nine had poor stability, forty-two had fair stability, and five had good stability.

Other prestretching data are shown in Table I.

TABLE I

CONDITION OF MUSCLES ON EXAMINATION

Muscle	Poor	Fair	Good
Quadriceps	78	28	4
Hamstrings	24	52	31
Gluteus maximus	36	28	44
Calf	54	21	32

Forty-seven cases had equinus, thirty-two had dorsiflexion of the foot to only ninety degrees, and twenty-six had calcaneus deformity.

PROCEDURE

Several methods of stretching were used: fourteen knees were stretched under anaesthesia; fifty had stretching, with or without anaesthesia, followed by gradual correction in a wedging plaster; forty-seven were treated with wedging plaster alone.

The plaster was applied as illustrated in the text-book of Jones and Lovett. The wedging was done by cutting out a sector anteriorly and making a transverse cut posteriorly. Medial and lateral hinge points were left in the plaster, usually over the femoral epicondyles and sometimes at the joint line. In some cases iron hinges were incorporated. Medial and lateral hinges over the epicondyles are best, because they overlie the approximate center of the arc which the tibia describes when it glides forward over the femoral condyles during extension. The knee was stretched gently once or twice a week and the position held by applying a cuff of plaster over a layer of crêpe paper. In a few cases an anterior turnbuckle, such as Kulowski has described, was incorporated.

The position obtained was ten to twenty degrees' recurvatum in thirty-seven cases, 180 degrees' extension or slight recurvatum in seventy cases, and flexion in four cases. A roentgenogram was not obtained in

every case, but those knees which were not put up in marked recurvatum are included in the second group. The time of retention in the corrected position was two months or less in twenty-nine cases, two to four months in sixty-six, and more than four months in sixteen.

RESULTS

Subsequent examinations were made from six months to five years after the removal of plaster. The period was three to five years in twenty-six cases, one to three years in seventy-seven, and less than one year in eight. The shorter periods were due to a second stretching or other operative procedure.

Anatomical Results

At the last examination seventeen knees were in definite recurvatum and nineteen in extension of 180 degrees. Together they constitute thirty-three per cent. of all the cases and may be regarded as excellent anatomical results (Table II). The follow-up period of this group averaged two and one-quarter years.

TABLE II

SUMMARY OF ANATOMICAL RESULTS

Anatomical Result	Cases	Per Cent.	Stability Increased
Excellent	36	33	68 per cent.
Improved	47	42	55 per cent.
Bad	28	25	21 per cent.
Total	111	100	

The alignment of the knee was improved in forty-seven other cases or forty-two per cent. In thirty-seven of them the flexion deformity was reduced to five degrees. In the other ten cases it was reduced to ten or fifteen degrees.

The flexion deformity recurred to the same angle as before stretching in sixteen cases and increased in twelve. These two groups together form twenty-five per cent. of the series and are listed as bad anatomical results.

Functional Results

The stability of the knee was increased in sixty-eight per cent. of the group of excellent results, in fifty-five per cent. of the improved group, and in twenty-one per cent. of the bad group.

In fifty-eight cases (54 per cent. of the entire series) the stability was improved. The improvement was from poor to good in nine, fair to good in twenty-three, zero to fair in three, poor to fair in eighteen, and zero to

poor in five. In forty-eight cases (44 per cent.) the stability was the same before and after stretching. In two cases (2 per cent.) the stability decreased. Increase of lateral relaxation was rare. In uncomplicated cases no knee was made less stable by stretching and many were made more stable. Furthermore, no knee was painful or swollen at the final examination and none had limited flexion. Posterior subluxation of the tibia was rare. Since the untoward results were negligible, it may be said truly that the stability of these knees, with reference to giving way on weight-bearing, was the index of the functional results.

ANALYSIS OF RESULTS

The degree of preoperative flexion deformity did not serve as an indicator of the result. The same percentage (*i.e.*, 64 per cent.) of the excellent-result and bad-result groups had five to ten degrees of flexion deformity. Sixteen per cent. of the excellent and none of the bad group had a flexion deformity of twenty degrees or more before stretching.

Duration of paralysis had no definite effect on the result, except that there was no excellent result obtained in the eight cases treated within four years of the attack of poliomyelitis.

Growth

The cases are divided into four age groups at the beginning of the knee-stretching procedure (See Table III). In Groups I and II the lower

TABLE III

ANATOMICAL RESULTS IN AGE GROUPS

Anatomical Result	All Cases	Group I	Group II	Group III	Group IV
		Female 3–5 years, inc. *Male* 3–6 years, inc.	6–11 years, inc. 7–13 years, inc.	12–14 years, inc. 14–16 years, inc.	15 years + 17 years +
Excellent (to recurvatum or 180 degrees)	32.7 per cent.	16 per cent.	22 per cent.	56 per cent.	46 per cent.
Improved (less flexion) ...	41.8 per cent.	34 per cent.	45 per cent.	32 per cent.	54 per cent.
Bad (same or worse)	25.5 per cent.	50 per cent.	33 per cent.	12 per cent.	0
	111 cases 100 per cent.	6 cases 100 per cent.	67 cases 100 per cent.	25 cases 100 per cent.	13 cases 100 per cent.

extremities were growing rapidly up to the time of the end-result examination. In Group III the growth was slowing down, and in Group IV the leg growth had stopped.

These groups are based on the findings of Royster, of Bean, and of Todd, and in many cases they were checked by actual measurements.

Loss of correction was much more frequent and more marked in the younger age groups (Groups I and II). In Group IV no case had complete loss of correction. In other words, loss of correction is more frequent in those patients whose legs are growing more rapidly.

Method

The method of stretching, whether rapid or slow, did not affect the result materially. There were three supracondylar femoral fractures caused by a single forcible stretching, but no epiphyseal damage was found.

Position and Time of Immobilization

Stretching to a marked recurvatum for two months or longer is more important than maintaining a less corrected position for a longer time. Thirty-one per cent. of the cases with excellent results were held in plaster in marked recurvatum for two to six months, but only fourteen per cent. of those with bad results were immobilized in this position. About the same per cent. (7.5 per cent.) of the excellent and of the bad cases were maintained in extension or slight recurvatum for four to six months. More of the knees with bad results were held in full extension or slight recurvatum for less than four months. The ratio of excellent to bad anatomical results was two and one-half to one in those cases which were immobilized in marked recurvatum for over four months; and it was one and one-half to one in those put up in merely a corrected position for the same time. These results show that overcorrection is better.

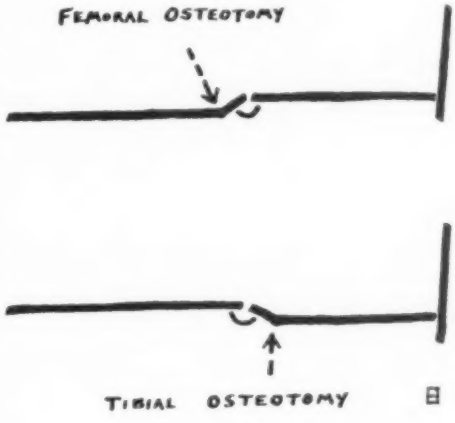

FIG. 1

The first note of recurrence of flexion deformity was made within one year in seventy-seven per cent. of the cases. It was progressive in nineteen cases, of which seventeen were in age groups I and II.

A Longer Leg

The length of the extremity was the same as that of the opposite leg or shorter in all cases with excellent anatomical results. It was longer in nine per cent. of the improved cases and in twenty-two per cent. of those with bad results. Therefore, a longer leg is a factor in recurrence. A longer leg did not interfere with knee stability; for, at the final examination, a greater number of the stable than of the unstable knees were found in the longer legs. The effect of length was indirect,—*i.e.*, through its influence on the recurrence of the deformity. The other factors which have been discussed similarly affected the functional results indirectly.

Other Procedures

Many cases had other operative procedures affecting the alignment of the extremity involved. In fourteen a supracondylar femoral osteotomy was done to correct knock-knee, and in thirty-seven a tibial osteotomy for torsion or for knock-knee and torsion was performed. The femoral or tibial fragments were put up in recurvatum in most cases. The percentage of each anatomical end-result group having such osteotomies, the degree of recurvatum (five to thirty degrees) and the correction of knock-knee or torsion were equally distributed. The conclusion is that the recurvatum in the fragments did not affect the knee-flexion deformity.

FIG. 2

Standing view, normal: *ip*, iliopsoas; *gm*, gluteus maximus; *q*, quadriceps; *h*, hamstrings; *c*, calf. Quadriceps maintains extension of knee.

This conclusion is stated with the following proviso,—many cases were put up with the femoral or tibial fragments in recurvatum, while the knee itself was in flexion. That fact was recognized in calculating the length of time of retention in a corrected position. In other words, the position of the knee joint proper was tabulated (Fig. 1).

Other procedures, the effects of which were shown in the end-result examination, were: subtalar arthrodesis, anterior tarsal section, anterior ankle block, ankle fusion, calcaneus-tendon lengthening, tendon transplants of dorsiflexors of the foot, and open hip-flexion release. No muscle transplants were done at the knee.

In eight cases a subtalar arthrodesis had been performed with resulting loss of equinus; all of these had a partial or complete recurrence of the knee-flexion deformity. In six cases a subtalar arthrodesis had been done with removal of calcaneus deformity; this resulted in varied knee positions, but improved the knee stability only when the knee was corrected. The same held true for anterior ankle blocks, which were effective in five out of seven cases. In one case the block failed because of pain; but, after the ankle had been fused in equinus, the stability of the knee, which was already in recurvatum, changed from poor to good.

In four other cases ankle fusion was done after the use of an equinus plaster boot without heel had shown improved knee stability. The analysis of the foot operations demonstrates that procedures which limit dorsiflexion of the foot tend to improve knee stability, but do not compensate for failure to reduce knee-flexion deformity.

Weight Thrust

Equinus without tibial torsion tended to extend the knee, as was evident from the fact that it was present in forty-six per cent. of the

excellent and in four per cent. of the poor anatomical results. Equinus with torsion was not effective. Calcaneus did not affect the knee position.

The effect of dorsiflexion of the foot and external tibial torsion (or rotation) on the knee stability is also interesting (Table IV). A torsion of less than fifteen degrees was disregarded, as was a torsion neutralized by varus of the foot.

Equinus deformity stabilized the knee, but its effect was lessened by torsion, as is demonstrated in Table IV.

Ninety degrees of dorsiflexion was a less effective stabilizing agent than equinus and was similarly modified by torsion. Calcaneus deformity lessened knee stability, especially without torsion.

More of the cases with excellent anatomical results had poor calf

FIG. 3

FIG. 4

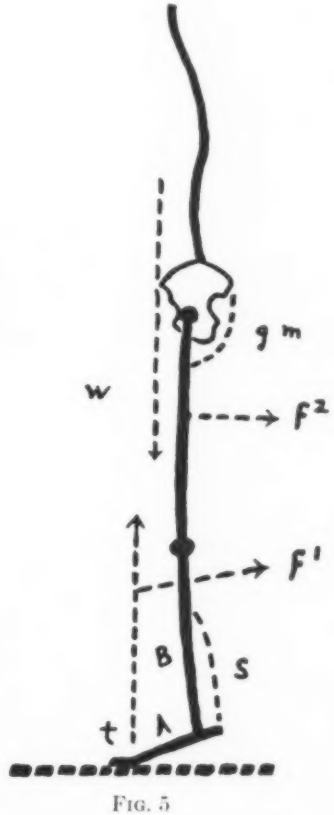

FIG. 5

Fig. 3. Standing view, recurvatum. Body weight (*w*) falls in front of knee, extending femur on tibia.

Fig. 4. Standing view, flexion deformity. Body weight (*w*) falls in back of knee, flexing femur on tibia. (Hip flexes also.)

Fig. 5. Walking, quadriceps paralyzed.

Gluteus maximus (*gm*) extends hip, stabilizing femur through force f^2; it also stabilizes pelvis when body weight (*w*) is shifted forward.

Equinus deformity, or soleus portion of calf (*s*), makes *AB* a rigid frame. Upward thrust at *t* (weight thrust) tends to rotate *AB* in clockwise direction, forcing upper end of tibia backward and extending knee through force f^1.

TABLE IV

ANALYSIS OF FACTORS AFFECTING STABILITY OF THE KNEE

Stability of Knee	No. of Cases	Equinus Without Torsion	Equinus With Torsion	Dorsi-flexion to 90 Degrees Without Torsion	Dorsi-flexion to 90 Degrees With Torsion	Calcaneus Without Torsion	Calcaneus With Torsion	Either Equinus or Good Calf or Both	Neither Equinus nor Good Calf Muscle
		Per Cent.	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*
Good.....	39	46	14	22	8	2	8	72	28
Fair.....	38	30	19	16	5	16	14	60	40
Poor.....	26	4	17	17	25	29	8	23	77
0.....	6	0	17	0	50	33	0	17	83

muscles and more of the bad cases had good calf muscles, indicating that calf power is a factor causing a recurrence of the flexion deformity. However, it does not have the same influence on stability of the knee. The presence of both equinus and good calf muscle, or either of these factors, stabilized the knee, while the absence of both tended to make the knee unstable. This conclusion is based on the last two columns of Table IV. The effect of equinus and calf power is seen at a glance. It is also evident that other factors must affect the stability.

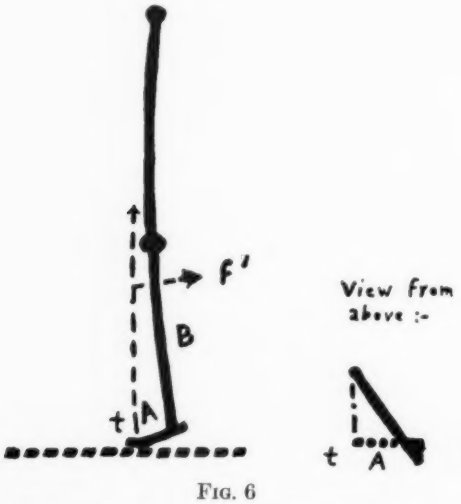

FIG. 6

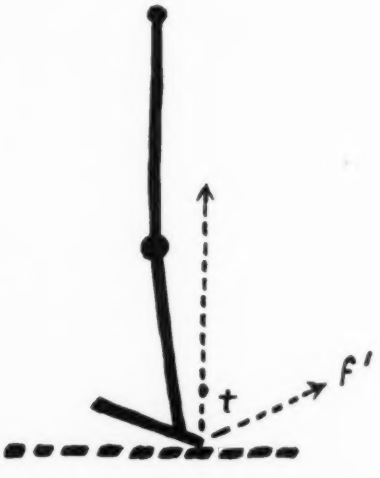

FIG. 7

Fig. 6. Walking, quadriceps paralyzed.

Equinus with tibial torsion (or rotation) foreshortens *A*, so that moment of force (*t*) is small, and force f^1 is weak.

Weight thrust tends to screw tibia into more external rotation and knee into valgus and flexion.

Fig. 7. Walking, quadriceps paralyzed.

Calcaneus: weight thrust (*t*) is at heel, and component (f^1) acts on lower end of tibia, flexing knee.

Quadriceps Power

Power in the quadriceps muscle gave better anatomical and functional results. However, about the same percentage of cases with excellent, improved, and bad anatomical results had poor quadriceps muscles, and more of the excellent than of the other groups had a marked muscle imbalance between quadriceps and hamstrings. Therefore quadriceps paralysis was not incompatible with maintenance of correction.

The final examination of the knees for stability showed the following relations between recurvatum or flexion deformity and quadriceps power:

(1) All knees in recurvatum, regardless of quadriceps power, had fair or good stability.

(2) All knees with good quadriceps muscles had good stability.

(3) Some knees with 180 degrees' extension and paralyzde quadriceps muscles were stable and some were unstable.

(4) Many knees with flexion deformity and paralyzed quadriceps muscles had fair or good stability.

(5) The stable knees were equally divided as to position and quadriceps power.

It is obvious, therefore, that these factors alone did not determine the stability.

Gluteus-Maximus Power

Table IV shows that twenty-eight per cent. of the good, stable knees had neither equinus nor good calf muscles. Of those eleven cases, two had fair quadriceps muscles and the others poor. Seven had good and three fair gluteus maximus muscles; in one the gluteus maximus was poor, but that case had a fully extended knee and dorsiflexion to ninety degrees without torsion. Nine of the eleven cases had full extension or recurvatum; and the other two had mild knee-flexion deformity but good gluteus maximus muscles and ninety degrees' dorsiflexion without torsion.

Of the twenty-eight cases (72 per cent.) with good stability, which had both equinus and good calf muscles, or either of them, only one had a poor gluteus maximus. Four of the twenty-eight had marked knee-flexion deformity but powerful gluteus maximus muscles.

Analyzing each group of the table we found in all of them that gluteus-maximus power was a most important stabilizing factor. However, the pull of that muscle was not sufficient to maintain recurvatum. The same proportion of the excellent and the bad anatomical result groups had good gluteus-maximus muscles. The gluteus medius and gluteus minimus did not have any effect on knee extension or stability.

Other Factors

Hip-flexion deformity was present in six per cent. of the cases showing excellent and in twenty-five per cent. of those with bad anatomical results, suggesting that it tended to prevent maintenance. Its correlation

with gluteus-maximus paralysis was not close in the final examinations, for it had become mild or altogether lacking in most cases. It was the gluteus-maximus weakness, and not the mild hip-flexion deformity, which was detrimental to knee stability.

Knock-knee was found in more of the knees which flexed again, and seemed to prevent maintenance of correction. Indirectly, therefore, it affected stability.

Restretching of the knee, which was done in ten cases, was more effective than the first stretching and wedging procedure, without anything else having been done. The results were cumulative, and the increased extension improved the stability.

SUMMARY OF FACTORS

Anatomical Results

Summing up the anatomical results, we are convinced that the factors causing the maintenance of correction are, in the order of their importance:

1. A good stretching, the best being to recurvatum for two to six months.
2. Age beyond that of rapid growth of the leg.
3. A good quadriceps.
4. Equinus without torsion.
5. Restretching.

The factors causing recurrence are:

1. Incomplete correction for too short a time.
2. A longer leg.
3. Rapid growth of leg.
4. Knock-knee.
5. Hip-flexion deformity.
6. A good calf muscle.

Functional Results

From the study of the functional results, we have shown that the factors making the knee stable are, in the order of their importance:

1. A good quadriceps.
2. Recurvatum or full extension.
3. A good gluteus maximus.
4. Equinus without torsion.
5. A good calf muscle.

Diagrams are presented to illustrate those factors.

SUBLUXATION OF TIBIA

It has been said that a posterior subluxation of the tibia on the femur is a frequent result of knee stretching. This we have found not to be the case in knee stretching after poliomyelitis. In the normal knee, in extension, the tibia glides forward over the femoral condyles until the menisci impinge on the transverse grooves; it does not articulate with the

surface of the patella. Following poliomyelitis, there is a change in the conformation of the bones of the knee. The anterior bowing of the femur displaces its tibial articular surface backward. In complete extension, there is usually an apparent posterior subluxation of the tibia on the femur, and it is more pronounced when an external-rotation deformity of the tibia makes the fibular head project posteriorly (Fig. 8). Study of roentgenograms reveals that this is not a true subluxation. A tibial osteotomy with the fragments in recurvatum takes out the anterior bowing at the upper end of the tibia and substitutes for it a posterior bowing, which again gives the appearance of subluxation (Fig. 9). Such apparent subluxations, or even the few slight actual ones, had no effect on the recurrence of flexion deformity or the stability of the knee in this series of cases.

FIG. 8

FIG. 9

DISAPPEARANCE OF HIP FLEXION

Hip-flexion deformity was corrected by operation in two cases out of four, and it disappeared without operation in fourteen out of thirty-three. Whether or not the knee stretching was effective had no bearing on this condition. Possibly the weight of the plaster stretched the hip.

RÉSUMÉ

The study verifies the idea that a knee with a paralyzed quadriceps muscle is stabilized by maintaining recurvatum. The method of stretching here considered is most likely to be permanent when the knee is put into marked recurvatum and retained in plaster for two to six months.

In some cases, even after a good stretching, the deformity recurs, either wholly or in part. Therefore, the selection of cases is important.

Those cases in which equinus without torsion is present, or in which such conditions can be obtained, are good subjects. When the leg is longer than the other before the stretching, or when the extremity is growing rapidly, the deformity is more likely to recur. Then a second or even a third stretching is necessary and will improve the knee position. Hip-flexion deformity may disappear; but, if severe, it should be corrected. Knock-knee should be corrected.

In cases where the duration of paralysis has been over two years, it is not possible to give the patient a good quadriceps. But in those which have the favorable situation described, it is possible to get and maintain a back-knee and thus stabilize the knee.

The first essential for stability, with a paralyzed quadriceps muscle, is recurvatum. Stability is enhanced by a good gluteus maximus; by

equinus deformity, especially without tibial torsion; and by a good calf muscle; even when the knee extends to only 180 degrees or is in slight flexion.

Thus, cases should be selected also with a view to the possibility of stability after stretching. Power in the gluteus maximus, quadriceps, or calf muscles will add to the prospect of success. The alignment of the extremity can be changed by operative procedures to produce the other factors of stability.

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A NEW OPERATIVE TREATMENT FOR FRACTURE OF THE OLECRANON

BY CHARLES ROMBOLD, M.D., WICHITA, KANSAS

Having been unable to locate in the literature a description of this procedure, the author presents a new technique for suture of a fracture of the olecranon.

The skin incision extends from two inches distal to the olecranon to five inches proximally, and is curved either laterally or medially to avoid the olecranon. The skin and subcutaneous tissue are reflected widely, exposing the ulna, the fracture, the olecranon, and the triceps tendon. The old clot is cleaned from the fracture.

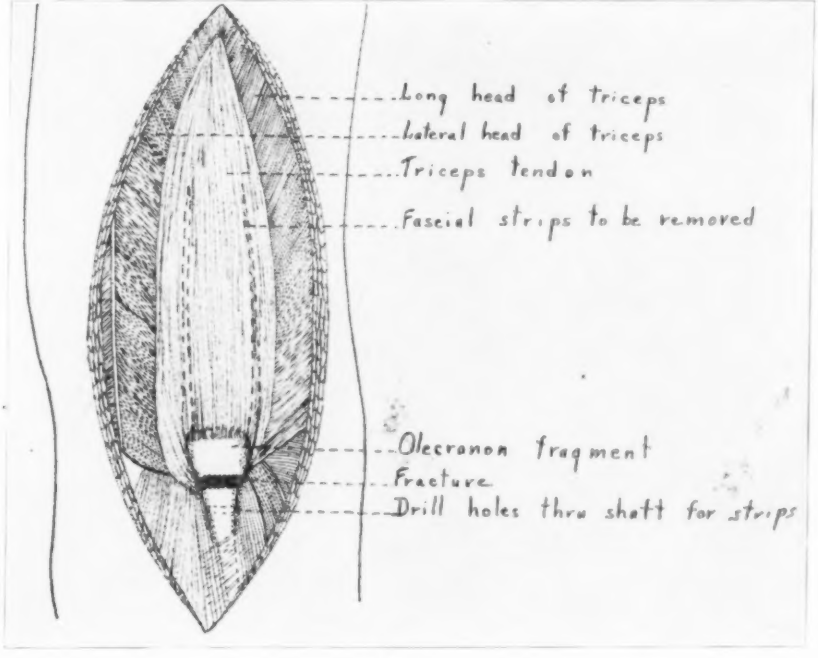

FIG. 1
Source of fascial strips.

The shaft of the ulna is drilled one-half an inch distal to the fracture and well in front of the posterior cortex.

Two strips of triceps tendon are used for the suture of the fracture. These strips are one-quarter of an inch wide and three inches long. The proximal ends, the edges, and the muscle-apposed surfaces are freed, leaving intact their insertions at the lateral and medial surfaces of the olecranon.

FIG. 2

Roentgenogram showing fracture of olecranon with marked displacement.

FIG. 3

Roentgenogram taken three months after reduction by the method described.

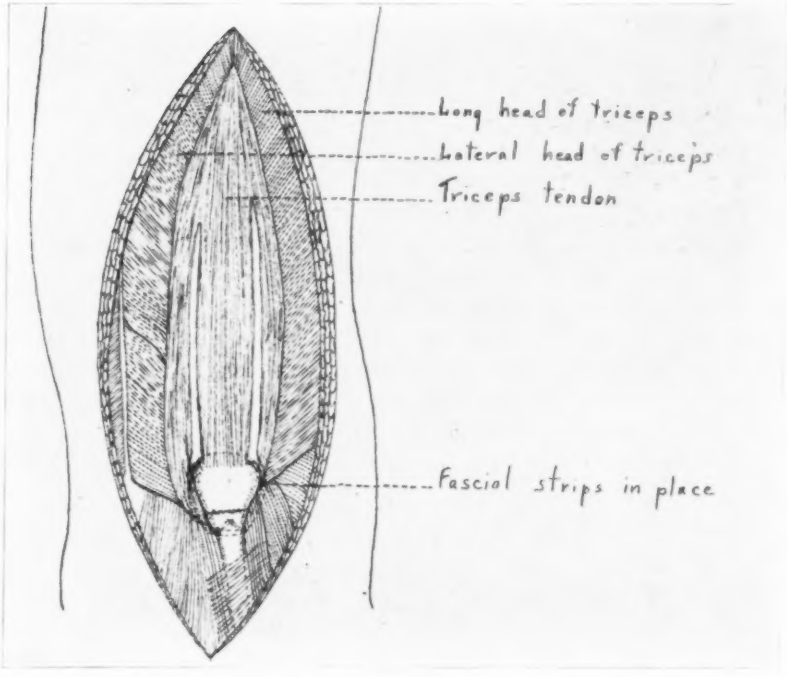

FIG. 4
Fascial strips in place.

The lateral strip is passed through the drill hole from the lateral to the medial surface, and the medial strip is passed from the medial to the lateral surface. They are then tied to each other and sutured through the knot after the fractured fragments have been snugly fixed in position. The wound is closed in layers.

The arm is carried in a sling for a week to ten days. After four or five days use up to the point of pain is encouraged.

The advantages of this method of suture of a fracture of the olecranon are:

1. Adequate internal fixation without the use of a foreign body is assured.
2. A second incision to obtain fascial material for suture is unnecessary.
3. The single drill hole is in the large fragment in which it is easily accommodated.
4. Early function may be introduced because of the adequacy of the fixation.

Four patients have been operated upon with perfect functional results.

A SURGICAL APPROACH TO THE OBTURATOR FORAMEN

BY SETH SELIG, M.D., F.A.C.S., NEW YORK, N. Y.

Recently a patient presented herself with an osteochondroma of the obturator foramen, arising from the junction of the ascending and descending rami of the os pubis and growing into the pelvis. Because of the unusual site of the tumor, no standard approach seemed to be adapted to it. No reference to a similarly located tumor was found in the literature; the only pertinent reports were the numerous references to hernia of the obturator foramen. There are two methods of approach to an obturator hernia. One is through the abdomen, and this is the most common method because the hernia is usually discovered during a laparotomy for an undiagnosed intestinal obstruction. The other approach is through the thigh, using a vertical incision, mesial to the femoral vessels. The ad-

FIG. 1

Roentgenogram of the right pubic bone, showing the osteocartilaginous tumor extending into the pelvis.

ductor longus muscle is retracted inward, the space between it and the pectineus muscle is opened, and the sac is sought for behind the pectineus muscle. Neither of these methods appeared suitable for this case.

CASE REPORT

D. M., female, aged twenty-one, was admitted to the neurological service at Mt. Sinai Hospital on March 14, 1934. Her chief complaint was numbness of the right thigh.

The patient was apparently well until July 1933, when she suffered frequent attacks of nausea and vomiting, which responded to medication after several weeks. During this illness, roentgenograms of the chest and abdomen were taken. Those of the chest were negative, but the abdominal roentgenogram showed the presence of an osteocartilaginous tumor of the right pubic bone. The patient had later had several roentgenograms taken which showed no change in the tumor. About September 1933, she began to notice an occasional pain and sensation of spasm, starting near the region of the vulva and radiating down the anterior, medial, and lateral aspects of the right thigh toward the right knee. This pain was noticed especially on walking upstairs and gradually became more severe. Shortly afterward the patient, who is a telephone operator, began to experience numbness and tingling in the same area, especially after sitting in one position for a long time; this gradually became more marked. For the month previous to examination the numbness had been constant in the right thigh and had entirely replaced the pain and tingling in this region.

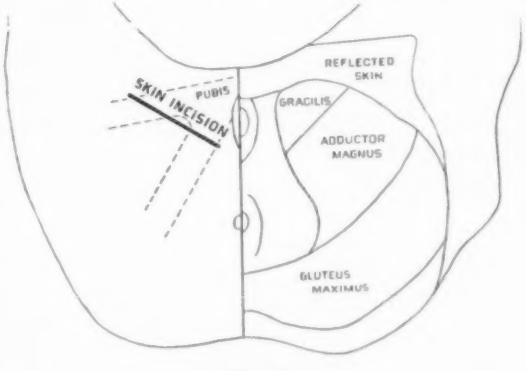

FIG. 2

Diagram of perineum. Left side shows the relation of the pubic bone to the skin incision. The right side is a diagrammatic sketch, with the skin dissected back to show the interval between the gracilis and adductor magnus muscles.

Physical examination was normal except for the following findings:

There was a well healed appendectomy scar and some tenderness in the right lower quadrant. On rectal examination a round, firm, tender mass was palpable on the right side. Sphincter tone was normal.

Neurological examination revealed anaesthesia for pain, touch, and temperature over the right thigh, except posteriorly where there was hypaesthesia to all forms of sensation. There was also hypaesthesia over the right saddle area. Position sense and vibratory sense were normal. The sensory distribution was atypical and unusual. There was slight weakness in extension of the right lower extremity and a slight limp.

Roentgenographic examination (Fig. 1) showed a bony expansion about the size of a quarter on the right side, extending from the surface of the vertical portion of the pubis toward the obturator foramen. This had the appearance of an osteochondroma.

Blood Wassermann and spinal-fluid Wassermann tests were negative. Because the stereoroentgenograms in this case showed that the tumor was pointing into the pelvis and taking origin from the junction of the pubic rami, the idea of approaching the tumor through the posterior aspect of the thigh, with the patient in the gynecological position suggested itself.

Operation: A four-inch incision (Fig. 2) was made on the posterior aspect of the thigh, perpendicular to the labia majora at its posterior aspect, exposing the dense fascia

lata which was incised in the same line as the skin incision. The interval between the gracilis and the adductor magnus muscles presented in the wound. By blunt dissection the muscles were separated, and the fibers of the obturator externus muscle were seen. At the mesial end of the incision the pubic bone was exposed. By separating the fibers of the obturator externus muscle from the pubis, the obturator foramen was cleared mesially. The osseous tumor was quickly and easily isolated, and removed with a piece of healthy pubic bone from which it grew. No vessel large enough to require a ligature was cut during the entire procedure. The incision was closed without drainage. Because of the proximity of the wound to the urethral opening and the rectum, the patient was made constipated for five days with deodorized tincture of opium and catheterized every six hours to prevent soiling of the dressing.

The pathological report of the tumor was osteochondroma. The patient made an uneventful recovery and her pain and hypaesthesia began to disappear within a week of the removal of the tumor.

What was feared would be a tedious and time-consuming operation proved to be easy and rapid through this approach. Whether it would be as effective in obturator hernia or in tumors arising from the lateral parts of the circumference of the foramen is questionable.

OSTEOGENESIS IMPERFECTA

A Report of Two Cases

BY SAMUEL KLEINBERG, M.D., NEW YORK, N. Y.

The following report is made for the purpose of recording two cases of osteogenesis imperfecta, each of which represents and is characteristic of a seemingly different stage of the same disease.

CASE REPORTS

Case 1 is a case of osteogenesis imperfecta congenita. Baby Geraldine W., two months old, was referred to the author in September 1933, by Dr. Harold Freeman, for the correction of deformities of all the extremities, due to healed but malaligned fractures present at birth. The correct diagnosis had been made by Dr. Freeman who, at the urgent request of the parents, wished to have the deformities of the limbs straightened, hoping that the infant might survive and would ultimately possess arms and legs of reasonably normal contour.

Family History: This was entirely negative in that there was no evidence of a similar malady in any member of the family on either parent's side for three generations back. There had been no consanguinity in the parents.

Present History: The child was born at full term by breech presentation. There was no history of antepartum injury to, malnutrition of, or any illness in the mother. The labor was not exceptionally difficult or prolonged. At birth the infant weighed five and three-quarter pounds, and appeared normal except for deformities of the limbs. She lost three-quarters of a pound during the first few days. As there was some difficulty about breast feeding, a formula was provided. The child began to gain in weight, and continued to do so slowly but steadily. At the end of the third month the infant weighed eight pounds.

Examination at the First Consultation: The patient was an undersized and underweight infant with a small face, a disproportionately large head, and distorted shortened extremities (Fig. 1). This illustration does not reveal the disproportion between the face and the head, which was conspicuous, and which became even more marked several months later.

The skull was symmetrical. The fontanelles were very large and the bones soft and abnormally thin and pliable.

The face was well formed and symmetrical. The sclera were slightly bluish, but not more so than is usual in an infant.

Trunk: There were no visible or palpable irregularities of the ribs or pelvis, and the mobility of the spine was normal.

The upper limbs were shortened, deformed, and held at right angles to the trunk. In the right upper extremity there was anterior bowing of the humerus, posterior bowing of the bones of the forearm, and easily palpable irregularity of these bones in the area of greatest convexity. There was no false mobility or crepitus. There was marked limitation of movement in all of the joints, but particularly in the shoulder. The left upper limb presented anterior bowing of both the arm and forearm with marked restriction of motion in all the joints (Figs. 1 and 2).

The lower limbs were markedly shortened and deformed. They were flexed at the hips and bowed acutely forward at the knees and at the middle of the legs (Figs. 1 and 2). The femora were bowed outward and forward. The tibiae and fibulae were angulated to almost ninety degrees at the middle third. The metatarsal bones were curved dorsally

to form a conspicuous projection on the dorsum of each foot. All joints were restricted in mobility and the limbs were quite sensitive to manipulation.

A roentgenographic study of the entire body (Fig. 2) revealed abnormal thinness of all the bones and deformities due to healed fractures of the long bones of all of the extremities. The bones appeared to lack mineral matter and were abnormally penetrable to the x-rays. The cortex was thin, hardly more than a line. The bone lamellae were atrophic and sparse. The sella turcica and the shadow of the thymus gland were normal.

A Wassermann test was negative. A blood chemistry investigation revealed normal findings as follows:

Calcium: 10.3 milligrams per 100 cubic centimeters of blood;
Phosphorus: 5.6 milligrams per 100 cubic centimeters of blood;
Phosphatase: 15.6 units.

This examination was made under the supervision of Dr. Bodansky of the laboratory of the Hospital for Joint Diseases.

As the child appeared in fair health and was gaining weight, it was assumed that she might belong to the small number who do well and continue to live, but the possibility that, like most infants with this condition, she might soon succumb to some intercurrent illness was explained to and appreciated by the parents. It was recalled that the literature records a number of instances in which the child lived to be several years old, and that Dr. Scott reported the case of a woman who had congenital multiple fractures, recognized as such at birth, and yet who lived to the age of fifty-five years. From this the writer took courage and urged that it was his duty to straighten the limbs. Gentle and slow correction of the deformities was advised. Accordingly, during five sittings, one or two weeks apart, each limb was straightened by gentle manual pressure. The correction was accomplished surprisingly easily, as only slight pressure was needed to overcome the bowing. Each limb, as it was straightened, was encased in a tiny plaster-of-Paris support. Finally the child was in a quadruple spica bandage (Fig. 3).

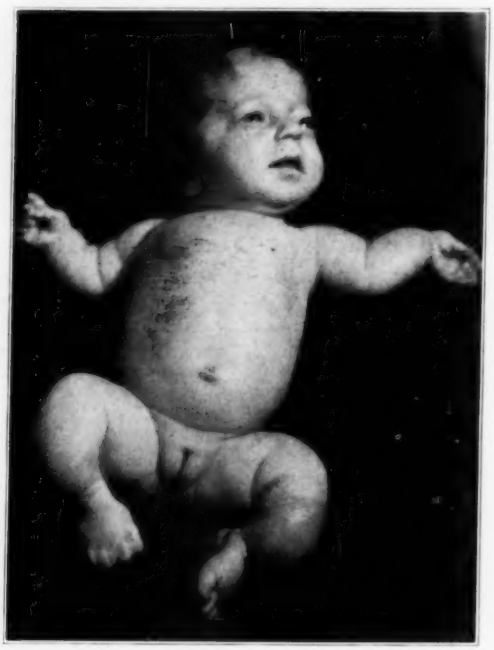

FIG. 1

Case 1. This photograph shows the deformities of all of the extremities. The disproportion between the face and the head is not seen in this picture. Note the marked angulation, almost to a right angle, at the middle of both legs, and the projection on the dorsal surface of the foot, the result of malaligned fractures. All the extremities are abnormally shortened.

While the limbs were being straightened, the child received adequate medical attention. She was receiving frequent exposures to the ultraviolet rays and was taking halibut-liver oil and viosterol under the direction of the attending pediatrician.

After some weeks it was noticed that the child was weakening. Her cry was a hardly audible whine. She took the usual amount of nourishment, but did not gain weight. In February, 1934, she contracted pneumonia and within a few days she expired.

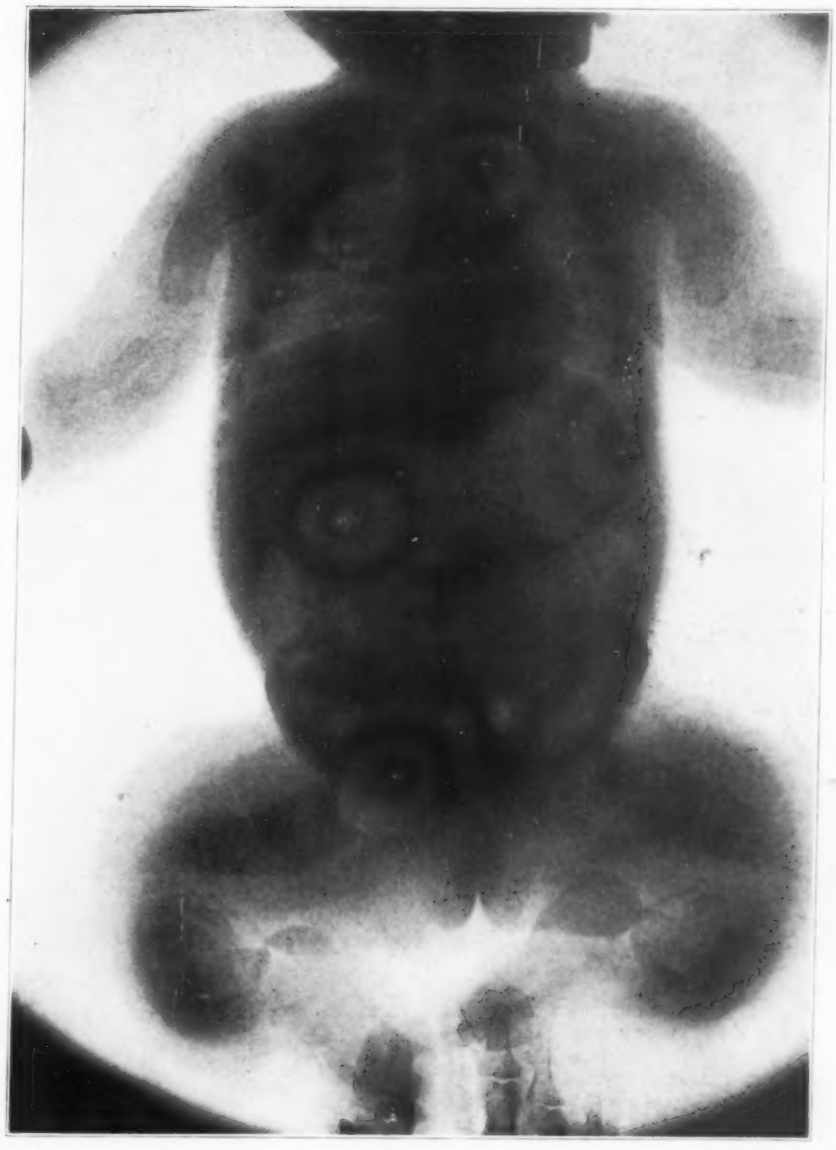

FIG. 2

Case 1. This roentgenogram shows the extreme generalized atrophy of all of the bones. The cortex of each bone is seen to be so thin that it is barely more than a line. The marrow cavity is much enlarged. The lamellae are thin, few, and sparse. Note the right-angled deformity of both legs and the shortening and angulation of all of the bones, particularly the femora and humeri.

CASE 2 is a case of osteogenesis imperfecta tarda, also called osteopsathyrosis and more commonly fragilitas ossium. Robert P., an only child, came under the care of the writer in July 1931, when he was two years of age. He was brought for advice because of inability to walk unaided, and of susceptibility to fractures from manifestly slight and insufficient causes.

Family History: The father, at about twelve years of age, broke his left elbow through a competent injury. Subsequently the elbow was fractured a half dozen times through slight traumata which ordinarily would not be sufficient to produce fractures. He never sustained fractures of any other part of his skeleton. The father is of short stature, but not abnormally so, and presents no deformities other than that of the left elbow. He has light china-blue sclera. The mother appears normal, although she too has a strong suggestion of bluish sclera. No other member of the family on either parent's side is known to have had any evidence of bone fragility.

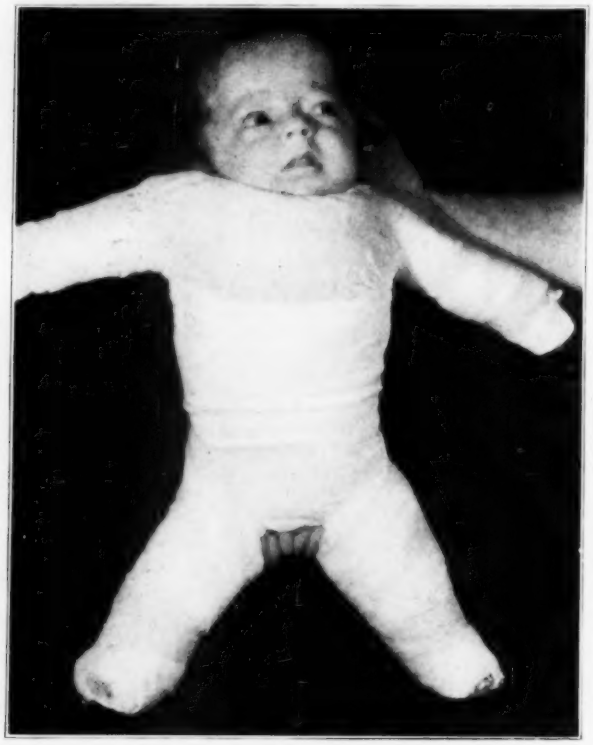

FIG. 3

Case 1. The patient in a quadruple spica with the deformity of the limbs greatly reduced.

The examination of the patient in July 1931 showed a fairly well developed boy of approximately normal height for his age. He had bow legs of a mild degree and he was unable to walk without assistance. He had deep china-blue sclera immediately suggestive of fragilitas ossium. His skull and face were symmetrical and well proportioned. His upper limbs, chest, abdomen, and back appeared normal. The ribs did not present any nodosities. The spine had normal mobility. In the lower limbs there was mild outward bowing of the legs, but normal motion in the hips, knees, ankles, and toes. Roentgenograms of the legs, pelvis, thighs, hands, and skull were available for inspection. These showed primarily a marked thinning, general atrophy, and increased radiability of the bones. The marrow cavity was wide and the bone lamellae thin, delicate, and sparse. The cortex was linear. The sella turcica was normal. The tibiae showed evidence of healed fractures with satisfactory alignment of the fragments (Fig. 4). A blood-chemistry study revealed normal findings for calcium, phosphorus, and phosphatase. The Wassermann test was negative.

The treatment of this patient consisted chiefly of guarding him from sustaining fractures. He was watched most carefully and continuously by his mother, and, although he did fracture his tibiae at different periods, he undoubtedly would have had many more fractures but for the inordinate and continual supervision. This child was given viosterol and ultraviolet-light treatment in the hope of toughening and increasing the resistance of his bones. It is difficult to estimate the value of the latter treatment. He did improve, so that he was soon able to be about and walk freely without any aid. Furthermore, the later roentgenograms showed what appeared to be an increase in the density of the bone. In addition, attempts to bend the legs manually showed the

presence of greater resistance. In January 1932 he refractured his right tibia and in January 1933 he sustained another fracture of his left tibia. All fractures healed rapidly —unusually rapidly, as is customary in this disease—and completely. It is peculiar that, just as the father of this patient broke his elbow several times but no other bones, so this patient has fractured only the tibiae and no other bones. Aside from the fragility of the tibiae, this boy has shown no abnormality.

SUMMARY

There have been recorded here two cases of osteogenesis imperfecta, one of which is of the so called congenital type in that the fractures, which constitute the main and gross evidence of the developmental defect, were present at birth; and the other is of the postnatal variety, retarded in its manifestations until several years after birth. Each case is characteristic of its type, particularly in regard to duration of life. The first patient, with the congenital fractures, died at the age of five months from an intercurrent respiratory disease. This is the usual fate of this class. Seemingly in this group there is not only a lack of resistance in the bones but a wide-spread, dangerous, and usually fatal lack of resistance that results in an early termination of life. The second patient, exhibiting blue sclera and bone fragility, presumably inherited the disease from his father. This boy, unlike the first case and the many reported in the literature, had exceptional fragility of only the tibiae which were the only bones fractured. This fact is difficult to explain, because the roentgenograms

FIG. 4

Case 2. This roentgenogram shows a marked degree of osteoporosis of the tibiae and fibulae, and also shows very clearly the atrophy and reduction in number of the bone lamellae. Incidentally it shows one tibia with a healed fracture.

showed about the same degree of atrophy in the other bones studied. This patient has done well, and, if he can be guarded through the period of puberty as well as he has been up to now, he will acquire the resistance against fractures that this group is known to obtain in adult life. Furthermore, in this type of osteogenesis imperfecta tarda, the general bodily resistance (It is unfortunately necessary to use such vague terminology) is quite satisfactory and gives no reason to anticipate any abbreviation of the life span.

While there is no suggestion, as yet, to explain the primary cause of the disease, we know that the chief change in the bone is a lack of complete development of the various constituents of bone tissue or, as Key describes the lesion, a hereditary hypoplasia of the mesenchyma. There is no specific therapy. Therefore, for the present, it is reasonable and worth while to utilize general therapeutic agents known to improve bone density and strength,—namely, viosterol given by mouth, and exposure of the body to the ultraviolet rays. This treatment was effective in the second case in which, after some months of treatment, the tibiae appeared less flexible than when the boy was first seen. In the first case, which was under the observation of the writer for three months, there was hardly time enough to effect any improvement.

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ACUTE OSTEOMYELITIS (OSTEITIS) OF THE PATELLA

A Case Report *

BY JACOB SAGEL, M.D., GARY, INDIANA

Osteomyelitis of the patella is a rare condition and this fact has been commented upon by numerous authors. Chesky, in 1923, was able to find only thirty-five cases in the literature besides his own case. Rocher found fifty cases and also added his own case, the only one he had seen in a series of almost 1,000 cases of osteomyelitis.

Since the disease is so rare, it would probably be of interest to mention a few of the more salient points:

1. Most cases occur between the ages of five and fifteen years, because ossification and circulation of the patella do not begin until four to five years of age. Circulation reaches its maximum at twelve years and ossification is complete at sixteen years of age.

2. The ratio of males to females is five to one.

3. Injury has been established as the cause in more than half of the cases of primary hematogenous osteomyelitis of the patella.

4. The density of the patella is 1.3; whereas the density of most spongy bone in which infective emboli lodge is 1.15 or 1.05.

5. The vessels which supply the patella are very small, so that emboli tend to remain in the main channel (main artery) rather than to be diverted by the slow moving shunt stream into the patella.

6. As a rule, the knee joint is not infected, although an aseptic effusion occurs quite commonly. This confirms the clinical observation that osteomyelitis rarely involves the neighboring joints.

7. The diagnosis is rarely made at the onset of the disease and usually not until a discharging sinus occurs. The clinical diagnosis in most cases is suppurative arthritis of the knee joint. Osteomyelitis associated with suppurative arthritis cannot be differentiated from suppurative arthritis alone except by roentgenographic examination.

8. A good functional result will be obtained if operation is done early. The functional result also depends on whether or not the knee joint is involved. If the articular cartilage of the patella is not involved, function of the knee joint will be good. If the articular cartilage of the patella is involved, function of the knee joint may be partly lost.

9. Preservation of the surrounding fibroperiosteum and deep bed of cartilage which protects the articulation favors regeneration of the patella.

10. The prognosis is generally good. As a rule, after radical intervention, we do not get recurrences as in osteomyelitis elsewhere.

* From the Department of Roentgenology of the University of Minnesota and the University Hospital. Presented before the Minnesota Radiological Society on March 10, 1934.

CASE REPORT

A boy, aged eight, entered the University Hospital on August 12, 1929, complaining of pain in the right knee. Two weeks before admission, he fell on his right knee, which, however, produced no abrasion of the skin. No discomfort followed until one week later when he began to have pain in the right knee which became red and swollen. In spite of continuous hot applications the condition of the knee became worse and his temperature rose to 101 degrees.

Physical examination showed an asthenic boy who was somewhat dehydrated. There was considerable oral sepsis and the tonsils were hypertrophied and showed evidence of chronic infection. The right knee joint was swollen, reddened, and very painful on slight palpation or movement.

Laboratory findings were as follows: normal urine on twelve examinations; hemoglobin, 74 per cent.; leukocytes, 23,500, of which 67 per cent. were polymorphonuclear.

The clinical diagnosis was septic arthritis, although suprapatellar bursitis and tenosynovitis were also considered. Roentgenographic examination on admission, August 13, 1929, showed no evidence of involvement of the right knee joint (Fig. 1). The patella showed extensive rarefaction, indicating bone destruction, with a break in the contour on both its anterior and posterior surfaces. Only a small part of the patella anteriorly

FIG. 1

Anteroposterior and lateral views of the right knee joint. The right patella shows extensive rarefaction, indicating bone destruction, with a break in the contour of both its anterior and posterior surfaces. The dense shadow anteriorly is the remnant of the patella which is not involved. Soft-tissue swelling anterior to the patella is poorly shown. There is no evidence of infection within the knee joint.

was uninvolved. The findings were considered to be quite characteristic of acute osteomyelitis of the patella.

The following day the knee joint was aspirated and five cubic centimeters of clear straw-colored fluid was removed. No pus was found, indicating the absence of suppurative arthritis. Local treatment with heat caused the redness, pain, and swelling to subside gradually, and the temperature dropped to almost normal.

A second roentgenographic examination, on August 21, 1929, showed a little progression in the destructive process in the right patella. The knee joint again appeared normal.

A third examination of the right knee joint, on September 6, 1929, showed a little beginning repair of the patella (Fig. 2). The swelling anterior to the patella had decreased considerably since the previous examinations. Figure 2 also shows the opposite patella for comparison with the affected side. The striking difference in appearance between the normal and pathological patellae is clearly shown.

The patient's condition continued to improve and, just before he was discharged from the Hospital, a tonsillectomy was done. On discharge, September 9, 1929, the patient was able to walk without pain and the right knee was normal in size. There was no limitation of motion.

FIG. 2

Roentgenogram taken three weeks later. The mottled character of the right patella is again shown although now there is evidence of beginning repair. Some of the dense shadows are suggestive of sequestra. The adjacent roentgenogram shows the normal appearance of the left patella in very marked contrast to the affected one.

FIG. 3

Roentgenographic examination of both patellae, December 20, 1933, approximately four and one-half years after the onset of the disease. The film at the left shows a very small area of rarefaction in the anterior part of the patella, indicating the residue of the osteomyelitis. The size and contour are the same as the normal patella shown for comparison at the right. This film was made by Dr. J. A. Cosgriff who treated the patient after his discharge from the University Hospital, and it is reproduced through his kindness.

The patient was referred to his local physician, Dr. J. A. Cosgriff, for follow-up examinations. He was well until two months after discharge from the Hospital, when a draining sinus developed over the right patella. Examination disclosed a small sequestrum which was removed. This was followed by complete healing. At present there is no limitation of movement or pain in the right knee joint. Roentgenographic examination of both knee joints (Fig. 3), on December 20, 1933, approximately four and one-half years since the onset of his illness, shows only a very small amount of rarefaction in the anterior portion of the right patella, which represents the residue of the osteomyelitis. The patella appears to be the same in size and contour as its fellow. The roentgenogram shows very well that the growth and development of the patella were not impaired by the infection, and function of the right knee is entirely normal at the present time.

This case has several interesting features. The roentgenographic diagnosis of osteomyelitis of the patella was made early in the course of the disease. Roentgenograms taken one week after the onset of symptoms (two weeks after the injury) showed extensive destruction of the patella, due to acute osteomyelitis. To the author's knowledge this is the earliest diagnosis made of this disease. Chesky stated that in no case was the diagnosis made before the sequestrum formed and in most cases discharging sinuses were present. Our case followed the general rule that sup-

puration in the knee joint does not occur, but that aseptic effusion is common. This was proved by aspiration of the knee joint. Etiologically, this case falls into the large group of primary hematogenous osteomyelitis secondary to trauma. This case has been followed for an unusually long time, the total period of observation being almost four and one-half years.

The roentgenographic findings of this disease are fairly characteristic. Destruction of the patella is shown by areas of rarefaction and mottling. Sequestra are commonly found within these rarefied areas. Quite often there is a break in the contour of the anterior or posterior surface of the patella. Soft-tissue swelling, anterior to the patella, is generally found. If there is fluid within the knee joint, the patella will be displaced anteriorly.

While osteomyelitis of the patella is a rare condition, it should be considered as a possibility in the differential diagnosis of infections about the knee joint. Roentgenographic examination is the best method for establishing an early diagnosis of this disease.

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GIANT-CELL SARCOMA OF THE PATELLA

A Case Report

BY MYRON O. HENRY, M.D., MINNEAPOLIS, MINNESOTA

"Is giant-cell sarcoma a neoplasm or a product of inflammation and repair?" asks the Registry. In this type of tumor the bone is enlarged, and the cortex is thinned out, but there is no infiltration of the soft parts. As a rule, the ends of the long bones are involved. The tumor is extremely rare in the patella, according to Dr. E. T. Bell, Professor of Pathology at the University of Minnesota. The following case is presented because of its rarity and because it illustrates the influence of trauma in giant-cell tumor.

FIG. 1

Lateral view, showing multicystic enlargement of the patella. (Anteroposterior view was not diagnostic.)

Mr. A. W., aged thirty-nine, was a farmer by occupation. His family history was of no importance; past history was negative except for childhood diseases and pneumonia. The trouble in his right knee began twelve years previously, when he was struck on the right knee cap by a horse. The injury healed completely in six months. About five years ago he struck the same knee against a cement wall, and since then he has been bothered with constant pain, increasing weakness, and an occasional attack of "giving way" followed by swelling. For the past three years he has had constant pain in the knee and has noticed that the knee cap has been increasing in size, while his thigh grew smaller.

The local examination revealed enlargement of the right patella to about twice the normal size, with considerable

effusion in the suprapatellar pouch. There was tenderness to palpation over the internal joint line, and extension was accompanied by a click which was both audible and palpable. There was extreme atrophy of the quadriceps and no power of extension of the knee. The roentgenograms revealed an enlarged patella with areas of rarefaction throughout (Fig. 1).

On the history, physical examination, and roentgenographic study, a diagnosis of cystic degeneration of the patella was made, and operation was advised.

At operation the diseased patella was excised *in toto*. The cortex of the bone was intact, and the knee joint showed no other evidence of disease except a few arthritic spurs at the margins of the condyles. Because of the extreme atrophy of the quadriceps, the knee joint was arthrodesed.

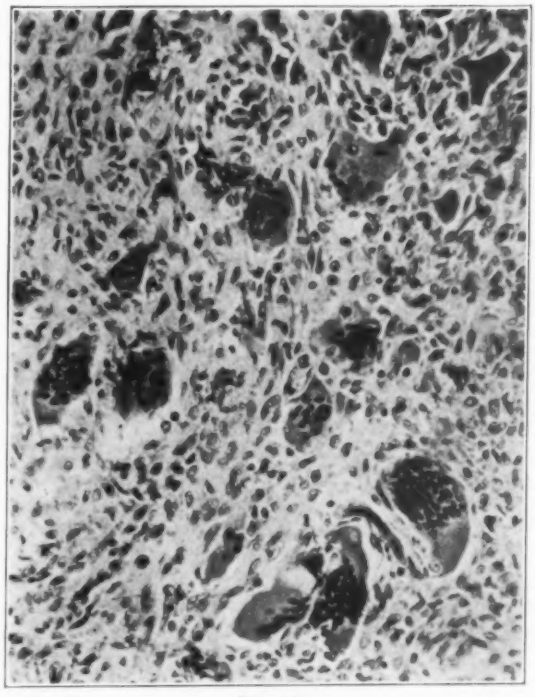

FIG. 2

Photomicrograph showing numerous giant cells in fibrous stroma.

On gross examination the patella was very large, but all of its surfaces were intact. On section the patella presented large cystic areas filled with a pale gelatinous material. Microscopic sections (Fig. 2), made by Dr. E. T. Bell, revealed abundant giant cells in a loose fibrous stroma and justified the diagnosis of giant-cell tumor.

RUPTURE OF THE BICEPS TENDON

BY G. I. BAUMAN, M.D., CLEVELAND, OHIO

Only four cases of tearing off of the biceps tendon from its insertion into the radius have been reported, which indicates the extreme rarity of this injury and warrants the report of each new case. As the surgeon encountering such a lesion has no precedent to guide him, he resorts to his own ingenuity; thus each report is accompanied by the description of a new method of making the repair. Strangely enough, the result in each case is reported as entirely satisfactory or perfect, indicating that one has only to replace the tendon in its normal relationship with the radius and other parts to obtain perfect healing.

The following case is reported to show a very simple and efficient method of making this repair.

C. G., male, aged forty-eight years, was seen on August 31, 1931, complaining of weakness of the right arm. Two or three days before, while lifting about 250 pounds, he experienced a feeling of tearing, followed by decided weakness on the flexor surface of

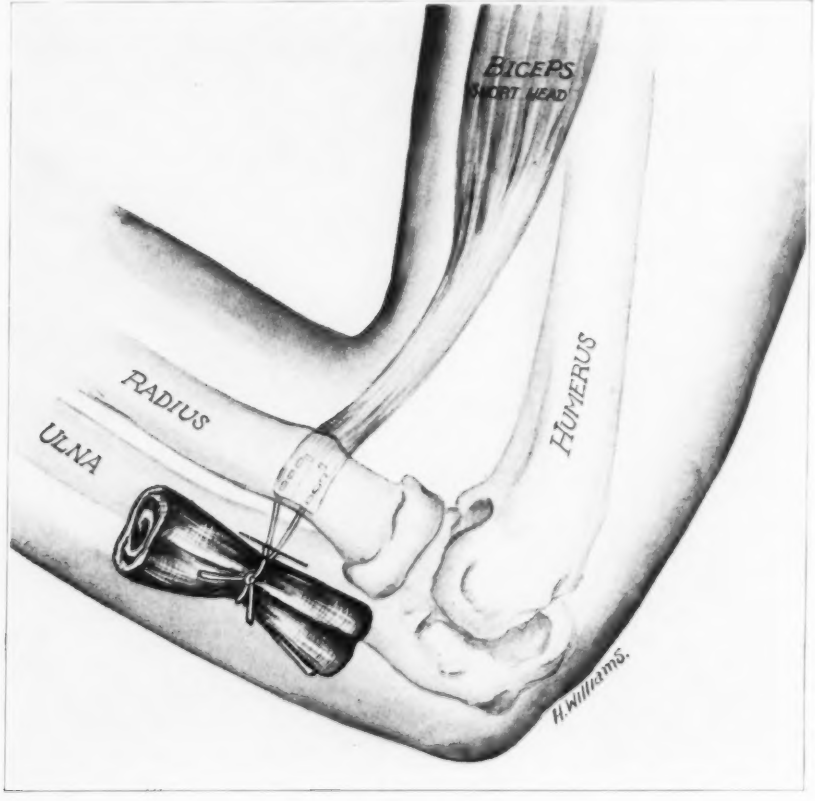

FIG. 1

the right elbow. At the end of twenty-four hours considerable ecchymosis appeared over the ulnar region of the forearm, just below the elbow. He also noticed a decided weakness in flexion of the elbow. There was not much pain.

The patient was a powerfully built man. There was a rather large area of ecchymosis in the region described above, but none on the flexor surface of the elbow. There was rather marked tenderness over the region of the biceps tendon, and this tendon could not be palpated. The patient flexed the arm fairly well, but seemed to do this with the supinator muscles. A diagnosis of rupture of the biceps tendon was made and suture was advised.

On September 1, the biceps tendon was exposed through an incision about six inches long over the flexor surface of the elbow. Considerable old blood was encountered in the upper part of the wound and, as this was expressed, the end of the tendon popped out from beneath the fascia. The end had apparently been turned back on itself and was lying almost in the middle of the arm; it was torn from its insertion in the radius. This region was exposed by tunneling under the fascia and a double No. 3 plain catgut suture was passed through and out via a small incision in the back of the upper part of the forearm. The end of the tendon was sutured to this catgut and the tendon was drawn down until the end was directly in contact with the surface of the radius from which it had been torn. The ends were then tied over a gauze pad in the back of the forearm. The deep fascia was closed with No. 1 catgut, the skin with No. 0. A posterior plaster splint was applied with the elbow acutely flexed.

After the operation there was some swelling in the forearm and hand, and the cast was split from the hand to just above the elbow. On September 5, the patient was quite comfortable, the temperature was normal, there was very little swelling, and he was allowed to go home.

On October 9 the cast was removed. The wounds were healed. The tendon seemed to be firmly attached to the radius, and there was good power of flexion and a little of supination. The elbow could be extended to about fifty degrees.

On October 24, union seemed solid and there was very good power in the biceps muscle. Several months later, the patient's physician reported the return of normal function and strength in the biceps muscle.

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A METHOD OF MAINTAINING TENSION IN SKELETAL TRACTION WIRES

BY EDWARD N. REED, M.D., SANTA MONICA, CALIFORNIA

In an attempt to devise a simple and inexpensive appliance to maintain the tension on Kirschner wires incorporated in plaster casts, experiments were made in order to find out what amount of sag occurs in such wires under ordinary conditions of their use in treating fractures.

Casts of the thickness ordinarily used in fracture work and two and one-half inches in diameter were constructed, and the wooden center around which they were built was removed. Wires were then introduced through each cast and their behavior, when pull was made on their center, could thus be observed inside of the cast. It was found that if the "tension bows", used to keep the wire taut while traction was made on the fragments, were left on, thereby maintaining the maximum tension on the wire, there was produced a sagging of about three-sixty-fourths of an inch by a pull of twenty pounds exerted on the center of the wire. If the tension bows were removed, the sag produced by twenty pounds of pull was found to be three-eighths of an inch.

A clamp was then threaded over each end of the wire outside of the cast, but inside the arms of the tension bow. These clamps were simply squares, or round discs, of cold rolled steel, five-sixteenths of an inch thick and one and one-half inches across, drilled through the center to admit the traction wire, and locked firmly to the wire by a set screw which entered the clamp at a right angle to the hole for the wire. Cup-pointed, case-hardened, set screws were used. The clamps were pressed firmly against the sides of the cast before they were locked onto the wire with the set screws. The stretching bow was then released and twenty pounds of pull was exerted on the center of the wire. It was found that the center of the wire sagged three-sixteenths of an inch.

If this amount of sag occurred in wires used to maintain extension in an oblique fracture, it might jeopardize the result. To obviate this, some users of wire traction advocate leaving on the stretching bows and incorporating them in the plaster cast for the entire period of fixation. The objection to this is that it ties up rather expensive apparatus and adds considerably to the weight and awkwardness of the dressing.

To avoid the need of retaining the tension bows in order to keep the wires taut, three holes were drilled in each clamp, at points representing the angles of a triangle, and threaded to receive jacking screws. To provide a suitable surface to receive the thrust of the jacking screws, and also to distribute this thrust over a considerable area of the cast, plates of thin steel (18 gauge) were cut about twice the size of the clamp, drilled at the center, and threaded over the wire on each side, ahead of the clamp. These plates were curved a little in their long axis in order to stiffen them.

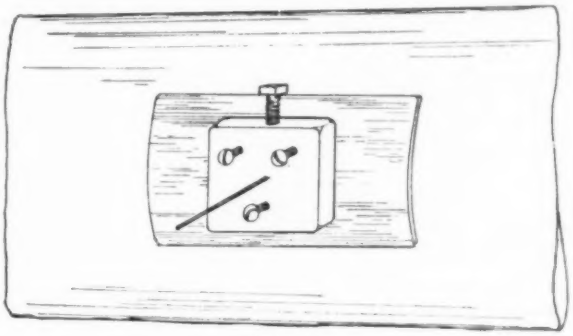

FIG. 1

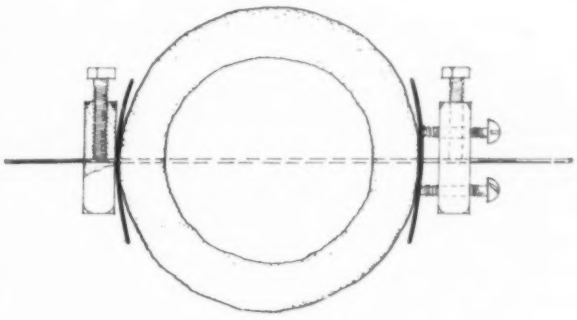

FIG. 2

After the clamps on each side have been firmly locked to the traction wire by the set screws, one of them can be backed away from the side of the cast simply by turning in the jacking screws. By so doing, a tension as great as that made by the tension bow can be set up; in fact, any amount of tension up to the point of forcing in the sides of the cast can be produced. Upon measuring with calipers the distance between the thrust plate on one side and the locking clamp on the other side, it was found that, with the exertion of the amount of pressure required to maintain such tension in the wire as would permit the minimum amount of sag (the same sag as when the tension bow was left on), the sides of the cast were compressed three-sixty-fourths of an inch. It is believed that this amount of compression would cause no trouble, since it could easily be accommodated by the padding under the cast.

It is sometimes necessary to release some of the tension on the wires in order to permit or encourage sag,—as, for instance, when, in the reduction, the ends of the fragments have been distracted to a point where they fail to make contact. In such cases, with the apparatus described, it is very easy to release the tension and to permit sag, thereby obtaining apposition of the fragments by simply backing off the jacking screws.

This method has the following advantages: (1) It is cheap—the entire apparatus can be assembled for a small sum of money; (2) it is not cumbrous, is light in weight, and simple in operation; (3) it obviates the necessity of tying up expensive and heavy tension bows in the completed dressing; and (4) the apparatus can be entirely covered with a couple of turns of plaster bandage, thus removing from the patient and his friends the temptation to tamper with the screws.

CORRECTIVE CAST FOR FLEXION-CONTRACTURE DEFORMITY OF THE KNEE

BY VERNON L. HART, M.D., MINNEAPOLIS, MINNESOTA

The purpose of this brief communication is to present a simple and very efficient method which the writer has used for several years for the correction of flexion-contracture deformities of the knees.

The writer claims no originality, since the corrective cast to be described (Fig. 1) is a modification of a method which Dr. Albert H. Freiberg, of Cincinnati, Ohio, described in 1918 [1].

A long plaster-of-Paris leg cast is applied with the knee in the position

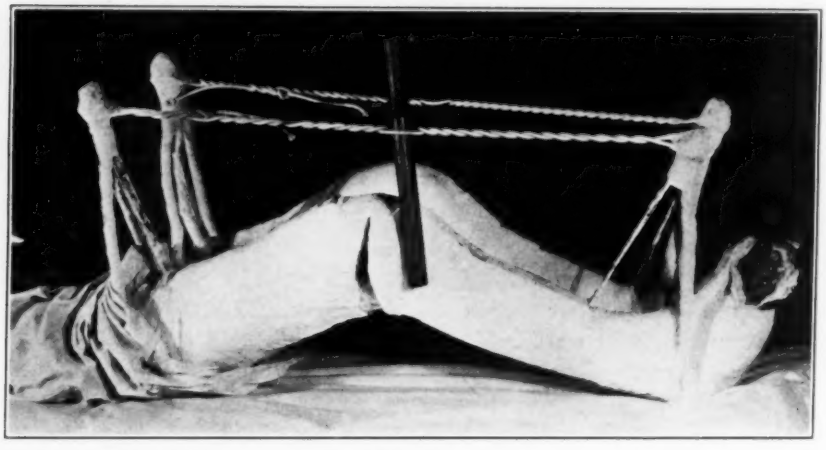

FIG. 1

Wedging casts for correcting flexion-contracture deformities of the knees.

of deformity and the foot at a right angle to the leg. Generous felt pads are applied over the heel, Achilles tendon, malleoli, patella, quadriceps tendon, and the proximal third of the thigh. Two pieces of mild steel, one inch wide, are bent at a right angle and incorporated in the cast, one proximal and the other distal to the knee. The projecting portions of the steel bars are bridged with a few feet of a heavy clothes line. The cast is cut so as to leave a hinge of uncut plaster just proximal to the patella. The plaster hinge should be about the width of the patella. As the cast is wedged, the hinge cracks. A piece of copper screen, two and one-half inches wide and six inches long, is incorporated in the plaster cast in order to prevent the plaster hinge from telescoping. Plaster ropes are added from the ends of the projecting steel bars to the cast in order to prevent the bars from bending as the tension on the clothes line is increased. Oc-

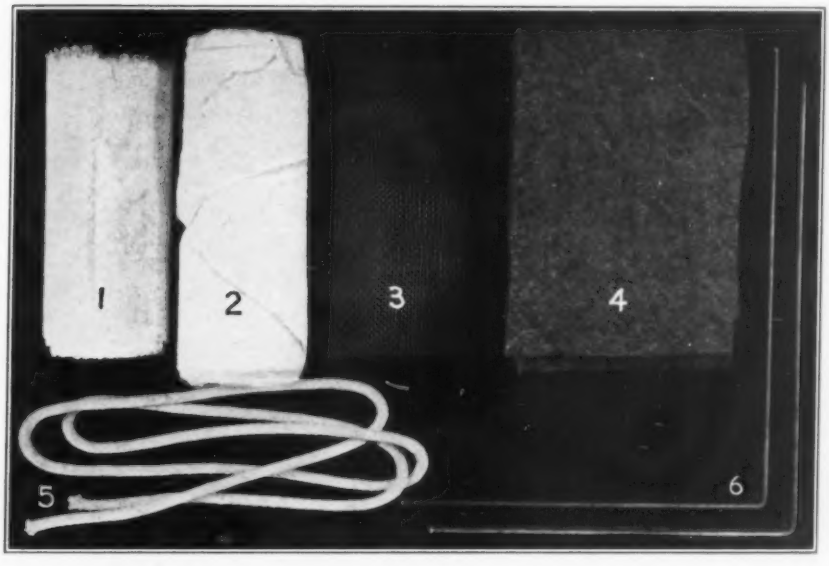

FIG. 2

Materials used in corrective cast:

1. Plaster.
2. Sheet wadding.
3. Copper screen.
4. Felt.
5. Heavy clothes line.
6. Mild steel bars.

A segment from a broom handle is also required.

casionally a wooden prop must be fixed against the knee side of either steel upright.

The patient is encouraged to frequently increase the tension during the day. The tension should be released daily and the knees returned to the original position in order to maintain motion. The tension should be relaxed during the night so as not to interfere with the patient's sleep and rest. The patient is instructed to actively contract the muscles controlling the knees and feet in order to maintain and improve muscle tone and power. Occupational therapy, physical therapy, heliotherapy and other measures to improve the patient's general health should not be neglected. A period of one or several months may be required to correct the flexion contractures.

The advantages of this method are that motion of the knee joints is maintained, the patient takes an active part in the correction of the deformities, and most of the period required for correcting the deformities may be spent at home.

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IMPROVED METHODS IN APPLYING THE KIRSCHNER PIN BY HAND OR ELECTRIC POWER

BY RALPH E. NIEDRINGHAUS, M.D., ST. LOUIS, MISSOURI

The principle of the Kirschner pin, as is well known, is to bring about a direct extension of fractures and to eliminate compression of the soft tissues by skin bandages, adhesive tape, casts, etc. The common method of penetrating the bone with the wire has been to drive the wire by means of hand drills which are long and cumbersome, and which are inclined to get off-angle and cause the wire to make its exit at a point other than that originally intended.

The writer has just completed a new type of hand drill (Fig. 1), with a spiral key-way drive, for Kirschner wire penetration. The drill in itself is

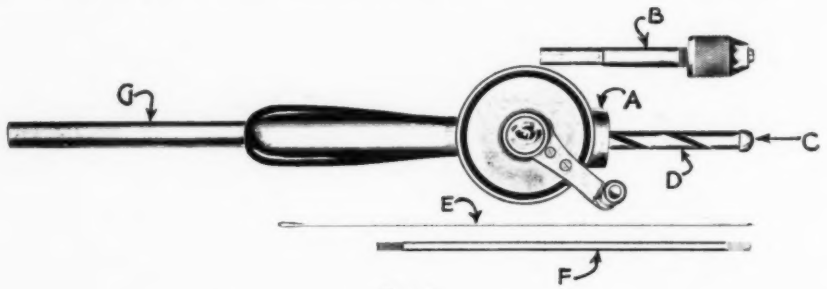

FIG. 1

A. Housing of ball bearing assembly
B. Adaptable chuck
C. Mouth of spiral key-way
D. Spiral key-way
E. Kirschner wire
F. Threaded rod which stabilizes adaptable chuck
G. Spiral key-way guard

shorter than the other types on the market and enables the surgeon to be closer to his field of work. The wire is placed in the mouth of the spiral key-way (Fig. 1, *C*) and, as it moves forward, the key-way recedes and is finally absorbed by the shaft of the drill. At the gear point there is a small ball-bearing assembly (Fig. 1, *A*) which permits smooth, continuous, penetration of the wire. The vibration or friction or "jerkiness" common in other types of drills is eliminated, and a precise and expeditious exit can be made from the bone.

As shown in the illustration an additional chuck (Fig. 1, *B*) accompanies the drill. The key-way drive can be removed and this chuck inserted in its place, making the drill adaptable as a twist drill for other types of bone work. The chuck sets into the shaft of the drill; and a rod (Fig. 1, *F*) with a threaded tip is inserted in place of the key-way guard (Fig. 1, *G*) and screwed through the base of the chuck, which is thus held firmly in position.

The drill is so constructed that it can be taken apart for sterilization or oiling with a minimum of effort.

In accordance with the theory employed in this new hand drill, a new drill attachment with an automatic feed for the Kirschner wire has been completed which is to be driven by motor. The purpose in making this drill, as in making the hand drill, has been to overcome the vibration and thus acquire the utmost accuracy in directing the pin to an exact point.

The construction of this drill can be clearly seen in the illustration (Fig. 2). The wire is rotated by the torque tube (Fig. 2, *A*) in which there is a spiral key-way (Fig. 2, *B*) of such pitch or lead that a forward thrust can be gently maintained by the thumb on the throttle (Fig. 2, *C*) situated on the back of the tube. Very little pressure need be exerted on the hand feed regulator or on the thumb throttle.

Experience has shown that with the use of either of these methods the Kirschner wire will bore evenly, accurately, and speedily into the field.

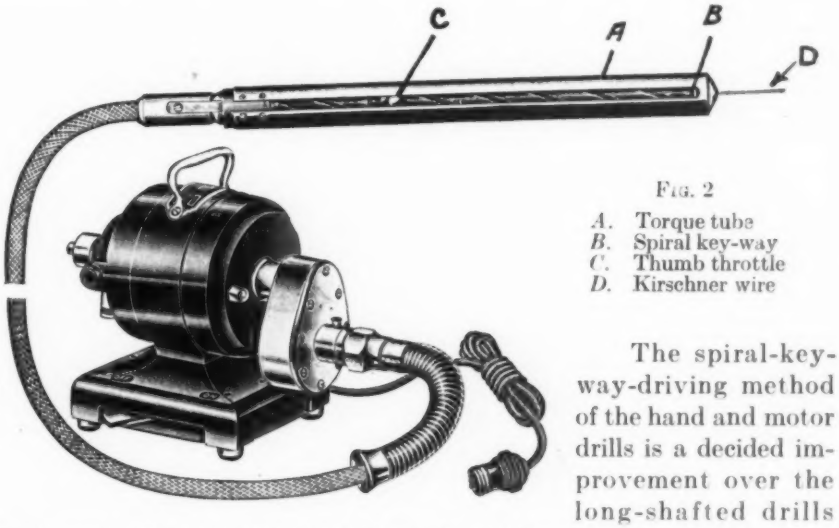

FIG. 2

A. Torque tube
B. Spiral key-way
C. Thumb throttle
D. Kirschner wire

The spiral-key-way-driving method of the hand and motor drills is a decided improvement over the long-shafted drills now in use. The vibration is eliminated, and the surgeon is able to make a precise and accurate penetration with the wire.

A DEVICE TO AID IN MAINTAINING PROPER ALIGNMENT IN PATIENTS IN RUSSELL'S OR BUCK'S EXTENSION *

BY BERNARD S. EPSTEIN, M.D., BROOKLYN, NEW YORK

The Jewish Hospital of Brooklyn

It has frequently been noted that there is difficulty in maintaining proper alignment in patients in either Buck's or Russell's extension. The cause for this is the tendency for the patient to be dragged down in bed by the weights. This has been particularly annoying in our younger, lighter patients, who have had to be pulled back into position frequently during the day and night.

The device here presented is suggested as a means of preventing the patient from sliding down in bed. Incidentally, it forms a valuable means of applying countertraction by allowing the patient to push himself back into position while traction is maintained.

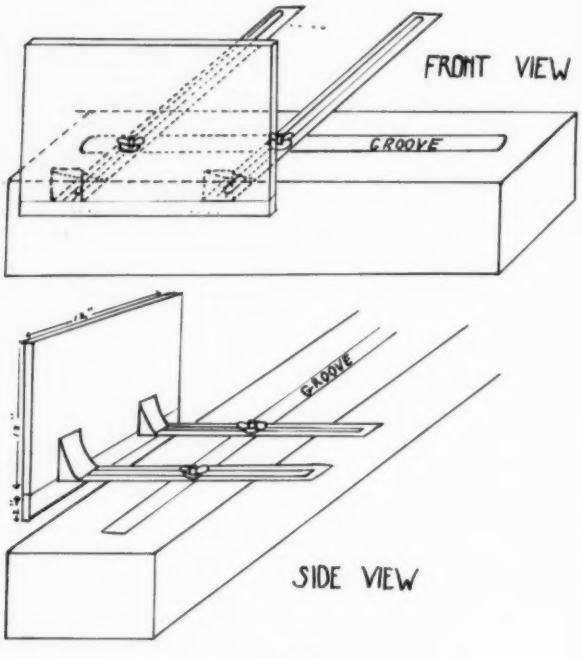

FIG. 1
Diagram of apparatus.

A rectangular wooden box is constructed with a groove in the top, as shown in the diagram (Fig. 1). The dimensions should be such that the top of the box is flush with the mattress, and the width sufficient to wedge the mattress firmly against the head of the bed.

A push board is made, firmly fixed to two wooden or steel grooved rods by right-angle irons. It is advisable to set the rods about two inches from the bottom of the push board, in order to assure contact between it and the mattress.

When in use, the push board is placed so that the patient's normal foot is in contact with it. Two thumb screws are sufficient to keep it

* From the Orthopaedic Service of Dr. B. Koven.

FIG. 2

FIG. 3

firmly in place, and the groove in the box makes it possible for the push board to be placed in any position desirable. The patient is then able to keep himself in one position by pushing himself up in bed whenever he feels himself slipping. Old patients can do this more easily if the weights are slowly lifted as they push themselves back.

This simple device to aid in maintaining Russell's or Buck's extension in proper alignment can easily be constructed in any carpenter shop.

SPLINTS COMBINING SKELETAL TRACTION AND COUNTERTRACTION

BY GEORGE W. HAWLEY, M.D., BRIDGEPORT, CONNECTICUT

The splints presented herewith speak for themselves. Figure 1 shows a splint for fractures of the shaft of the tibia. Sheet aluminum slings, padded with felt, are used to support the weight of the limb and prevent the sagging effect of gravity. The upper end of the tibia is transfixed, thus providing a fixed point of countertraction. A traction stirrup is applied to the lower end of the tibia. The lower fragment is movable and adjustable as to length, rotation, and change of angle, and may be brought into line with the fixed upper fragment. It is simpler to have the upper fragment fixed.

The form of stirrup used is a little different from the usual type. The stirrup (Fig. 6) acts as a guide as well as a stirrup. This determines both the point of inlet and the exit. The stirrup is adjustable to the diameter of the limb. It is put in place, adjusted to the width of the limb, and then transfixion is made, the stirrup being left in place after transfixion. This course reverses the customary method of transfixing the tibia and then applying the stirrup.

With this stirrup the surgeon has the choice of using a Steinmann pin or Kirschner wire,—it has one pair of screws for the pin and one pair for

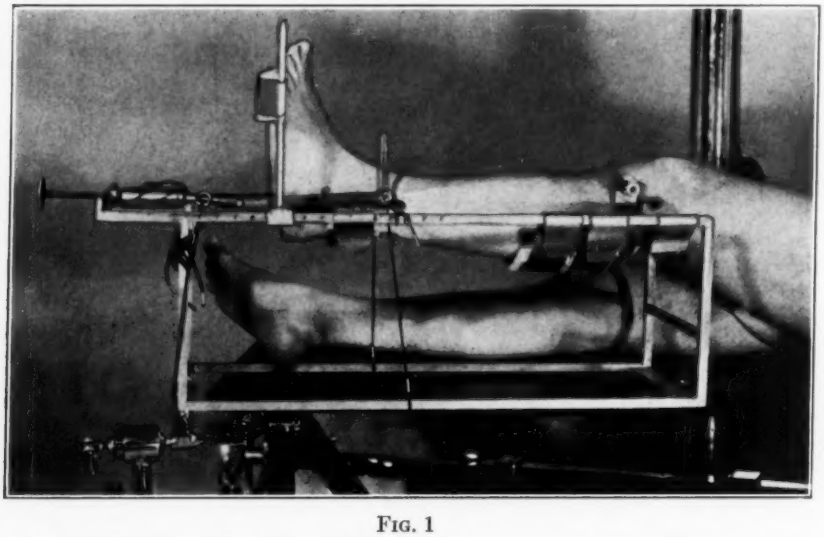

FIG. 1

Tibia splint. Transfixion of upper end of tibia as point of countertraction. Transfixion of lower end of tibia for traction. Exposure of leg for manipulation and for roentgenographic examination from below and from the side. Bars wide apart for plaster encasement. Splint shown on special fracture x-ray table. Can be used on any fluoroscope table.

wire, and they are interchangeable. Pins are preferred for the tibia and femur, and wire for the bones of the forearm. Small pins (one-eighth of an inch) are sufficient. With these stirrups the traction force comes nearer the center of the pin and not near the ends; thus small pins suffice.

Two types of traction are provided,—screw traction and spring traction. The surgeon has his choice. The spring traction may be used to measure and record the number of pounds required to restore length, or for gradual traction in old fractures. Screw traction may be substituted for spring traction when full length has been obtained. With the screw traction retraction is impossible, no matter how strong the muscle pull.

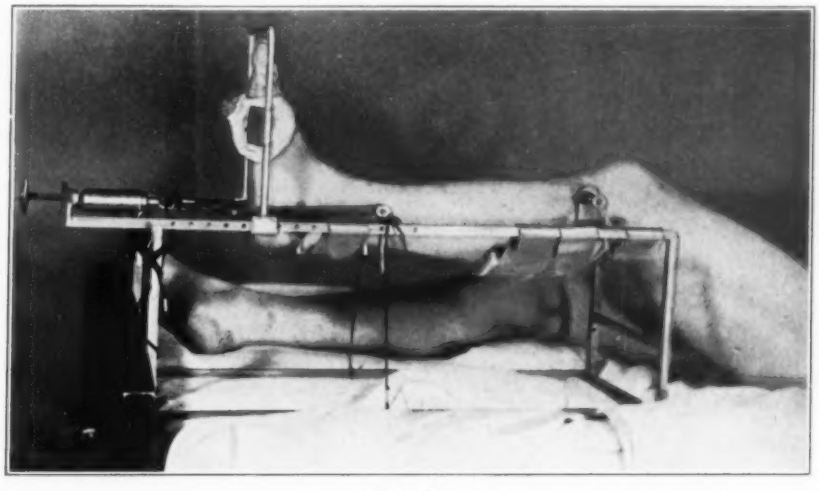

FIG. 2

Shows patient in bed with leg in splint. Splint is fastened to foot of bed. Exposure is permissible for fluoroscopy and roentgenoscopy and for secondary manipulation.

In a fresh fracture, the limb is placed in the cradle and roentgenograms are taken for diagnosis and record. Transfixion is then made and the surgeon observes and directs reduction through the fluoroscope. His assistant makes traction and regulates rotation and angulation under direction of the surgeon. The surgeon can view the fracture from above and from the side, as the leg is cradled so that the bones are above the lateral bars of the splint.

The limb is exposed so the surgeon can manipulate the fragments by hand. This is preferably done between x-ray exposures. The limb is also exposed for the treatment of compound fractures and surface wounds.

After reduction of fresh fractures, in cases with little swelling, the limb may be encased in plaster. Many times it is preferable to postpone encasement for a week or ten days, in order to observe possible atrophy of the fracture ends and to make sure of good fracture contact. In that case, the patient with the leg in a splint is removed to bed and the splint is secured to the end of the bed until such time as the surgeon thinks

plaster encasement advisable. When plaster is applied, the pins or wire are incorporated in the plaster. The stirrups may be released.

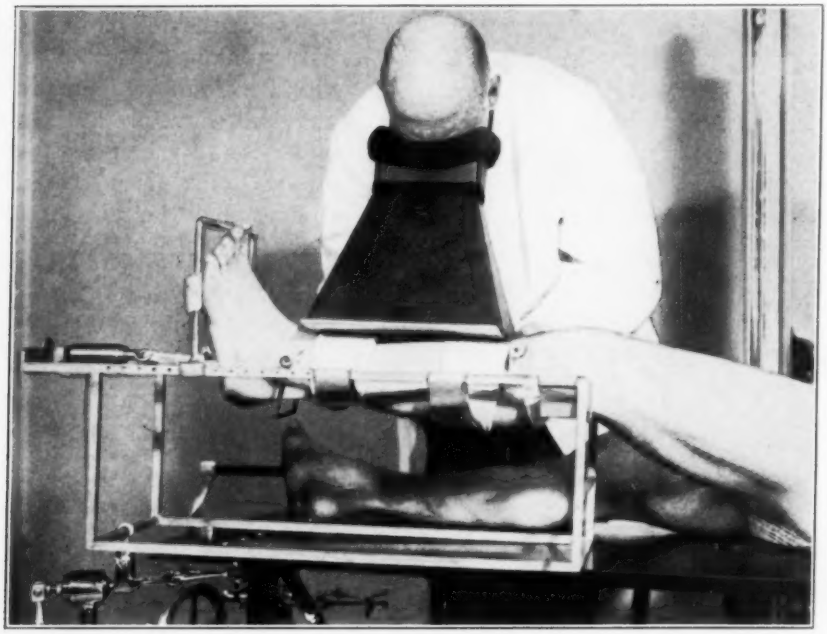

FIG. 3

Showing reduction under fluoroscopic control. Using a shock-proof x-ray tube from below, the rays are confined to a small area and are filtered on exit from the tube and on under surface of screen. Manipulations are made between x-ray exposures. Thus the surgeon's hands are not exposed. Low milliamperage limits the risk to the patient.

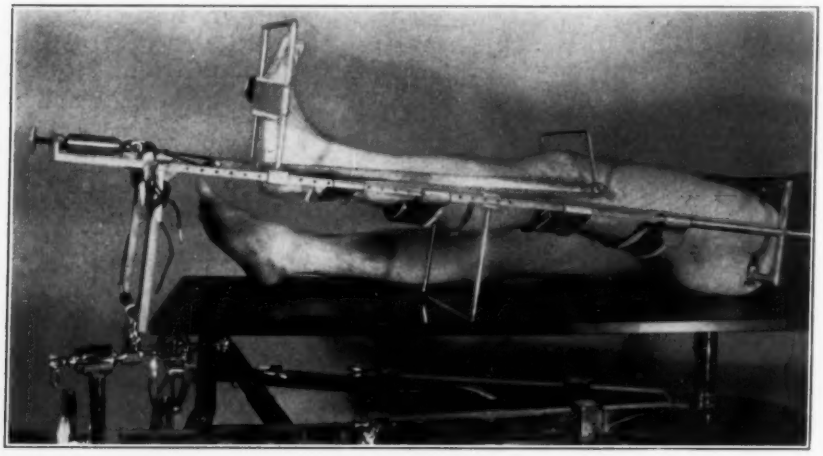

FIG. 4

Femur splint. Showing pin or wire transfixion of trochanter as fixed point of countertraction and transfixion of condyles for traction. Exposure is possible for manipulation and roentgenograms, and also for open operation.

The foot piece slides, and is used to prevent toe-drop and heel-cord contraction, to control rotation, and to check muscle spasm. After tendency to spasm has ceased, the foot piece may be moved down to allow ankle motion.

The bars of this splint are spaced nine inches apart to provide space for the application of plaster.

Figure 4 shows a splint for fractures of the shaft of the femur with transfixion of the trochanter for a fixed point of countertraction (after Putti) and transfixion of the condyles for traction. Other details of the technique are similar to those for the tibia splint described above.

FIG. 5

Forearm splint. Showing transfixion of the olecranon for countertraction. The stirrup is used for transfixion of the radius for traction. Wire is preferred for bones of the forearm with screw traction for control of bone length. The stirrup regulates rotation and locks in desired position of supination or pronation. Support under middle of the forearm prevents sagging. Exposure is possible for manipulation and plaster encasement.

Figure 5 shows a splint for fractures of the shaft of the bones of the forearm. The splint is made of aluminum and light in weight. It gives exposure for manipulation, roentgenographic examination, wound treatment, and plaster encasement. The central part of the forearm is supported by adjustable support from below. Rotation is controlled at the hand end of the splint. Free rotation and fixation are possible in supination or pronation, as desired, and may be changed at any time.

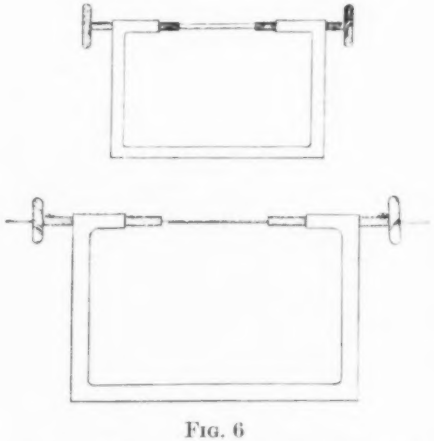

FIG. 6

Traction stirrup for either Steinmann pin or Kirschner wire. Stirrup acts as both guide and stirrup, as described in text.

Figure 6 shows the form of traction stirrup used with these splints. This stirrup is both guide and stirrup; the screws make it adjustable to the width of the limb. The screws also make the pin releasable and short pins are used. The stirrup is made square so that traction can be "on center" or "off center". Traction "off center" helps to correct angulation of fracture and can be regulated for this purpose.

Figure 7 shows a fracture lever for open and subcutaneous reduction. It combines traction with leverage and two-hand con-

trol. Bimanual control makes for reduced trauma and more effective application of force. This lever has a somewhat universal action. It can be used to pull or push, to lift or depress, as well as for leverage. Traction and leverage can be used at the same time, with very good leverage control and power. When used subcutaneously, the lever is introduced through a hole in the skin and guided to the site of fracture under the fluoroscope. The effect of traction and leverage is then observed and controlled.

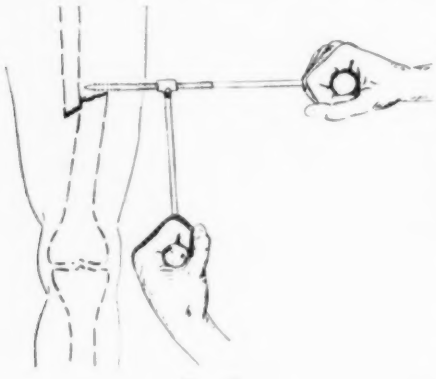

FIG. 7

Fracture lever, combining traction and leverage under two-hand control.

These splints may be used in the open treatment of fractures by surgeons who favor plating operations. By using preliminary skeletal traction and countertraction, full length is obtained before plates are applied. The operation is thus simplified, operative manipulation is reduced, and traction outside the operative field is regulated. These splints may also be used for bone lengthening. There is, however, this difference,—in fractures the traction is used to restore normal length of bone and soft parts; in bone lengthening, the traction is used to stretch muscles, fascia, nerves, and vessels beyond an established length.

OSTEITIS DEFORMANS, "PAGET'S DISEASE", WITH FRACTURE OF THE FEMUR AND PROMPT UNION*

Report of a Case

BY FRANK G. MURPHY, M.D., F.A.C.S., CHICAGO, ILLINOIS

From the Orthopaedic Department of the University of Illinois, College of Medicine

While it is generally accepted that osteitis deformans does not act as a deterrent to callus formation in cases of fracture, a review of the literature reveals no instances in which there was profuse and rapidly forming callus, with early union and function, in such cases during this disease. Georg Woytek states that osteitis deformans of Paget predisposes to fracture and even to spontaneous fracture. He cites fourteen cases of osteitis deformans, in seven of which fracture occurred. Of these seven cases, the fracture was due to trauma in three cases and was spontaneous in four. No comment is made in regard to the healing of the fractures.

As to the etiology of osteitis deformans, several theories have been proposed, but no definite evidence has been presented. Colt and Lyall treated one case with parathormone, with the idea in mind of overcoming a possible parathyroid deficiency. They state: "The only criterion we have of improvement is that x-rays during the past two years show less calcification. Also, patient herself feels better."

Several writers, including E. L. Compere and Walter Bauer, state that there is no evidence to show that the parathyroid has any significance in osteitis deformans.

The following case is presented because of several uncommon features: (1) a fracture in an unusual location, occurring from an apparently trivial cause; (2) the absence of severe pain and the comparative comfort of the patient from the time that immobilization was begun; and (3) early and profuse callus formation, with prompt union and function to the extent of complete weight-bearing in eight weeks' time.

Mrs. K. S., fifty-seven years old, well nourished, the mother of three children, tripped over a rug on April 12, 1933, and fell to the floor. She was immediately disabled and in pain. She does not remember how she struck the floor and states that the accident did not seem great enough to produce so severe an injury.

The past history revealed no serious illnesses. She had had a breast growth removed surgically at the age of thirty-one. In 1929, she had had neuritis pains in the left leg for one week. The only symptom that might be construed as attributable to the condition of the bone in the left leg was the presence of "neuritis" pains from January 1933 to the time of the fracture. She attributes the accident to difficulty in using the leg.

Physical examination: There was a moderate degree of bowing of both legs. There

* Presented before the American Academy of Orthopaedic Surgeons, Chicago, January 10, 1934.

FIG. 1

Roentgenogram taken April 13, 1933, one day after injury, showing fracture of femur. There is evident a fracture of the cortex and sclerosis intermingled with rarefaction extending into the pelvis.

was a mild degree of anaemia,—hemoglobin, 70 per cent.; erythrocytes, 4,040,000; and leukocytes, 13,200.

Roentgenographic examination: The roentgenogram taken on April 13, 1933, shows a transverse fracture of the shaft of the left femur about three inches below the lesser trochanter. There are also marked sclerotic and rarefying changes, with increase in size of the bone of the head, neck, and shaft of the femur, and of both ischial tuberosities, especially the left. These changes are characteristic of Paget's disease or osteitis deformans.

The roentgenogram of the skull taken on April 29, 1933, shows the typically thickened calvarium, and roentgenograms of the other long bones showed a thickened cortex, with intermingled areas of sclerosis and rarefaction.

Treatment: The patient was admitted to the hospital and placed under the care of Dr. F. O. Bowe. A modified Hodgen splint, with traction, was applied and maintained for sixteen days. At that time the author was called in consultation. A properly fitted Thomas splint, with sliding traction, was applied, in order that more efficient extension and better immobilization might be attained. Roentgenograms taken at this time showed good alignment, normal length, and fair reduction of the fragments. Medical treatment consisted of the administration of ten drops of viosterol three times a day and ten grains of calcium lactate three times a day. A diet rich in vitamins and calcium was prescribed.

The patient's convalescence in bed was uneventful; she was comfortable and complained of little or no pain. Periodic measurements of the leg were taken so that the length was maintained. At the end of seven weeks, a large amount of callus was palpable at the site of the fracture. The splint was removed on June 5, 1933, at which time there was solid bony union and the patient could voluntarily lift the leg from the bed. On June 12, she was allowed up on crutches and shortly afterward weight-bearing was permitted. On July 4, she walked with a cane, and on July 25, fourteen weeks after the injury, she walked without a cane or assistance. She continued to improve. Six months after the injury she had a slight limp, but stated that the uninjured leg was weaker than the injured one. At the last examination the patient stated that the "neuritis" pains occasionally occurred, but that she was able to do her own housework.

Roentgenograms taken August 1, 1933, show good union, with fair alignment of the fragments. There was apparently a hyperproduction of callus, which four months from the time of injury was almost as completely ossified as the adjacent bone.

FIG. 2

Roentgenogram of the tibia, taken April 29, 1933, showing ossification with intermingled areas of sclerosis and rarefaction.

Roentgenograms of other parts of the skeleton showed the condensation sclerosis intermingled with rarefying osteitis, which is so typical of osteitis deformans of Paget. There was slight bowing of both femora. The skull showed the markedly thickened walls of the vault, giving the typical "woolly-headed" appearance.

CONCLUSION

A case of osteitis deformans of Paget is reported, which presents several unusual features,—namely:

1. Fracture through upper third of femur from a trivial cause.
2. A rapid and uneventful convalescence.

FIG. 3

Roentgenogram of the skull, taken April 29, 1933, showing typical "woolly-headed" appearance.

3. Prompt union of the fracture with profuse callus formation.

4. Early return of function with full weight-bearing in eight weeks' time.

In view of the fact that in cases of osteitis deformans there are in the thickened cortex of the bone intermingled areas of rarefaction and sclerosis and a positive balance in the intake and output of calcium, it is apparent that there is an increase in bone metabolism. Therefore, it is not surprising that, in cases of fracture in such patients, prompt union occurs with hyperproduction of callus.

The author wishes to express his appreciation to Dr. Henry B. Thomas for reviewing this case.

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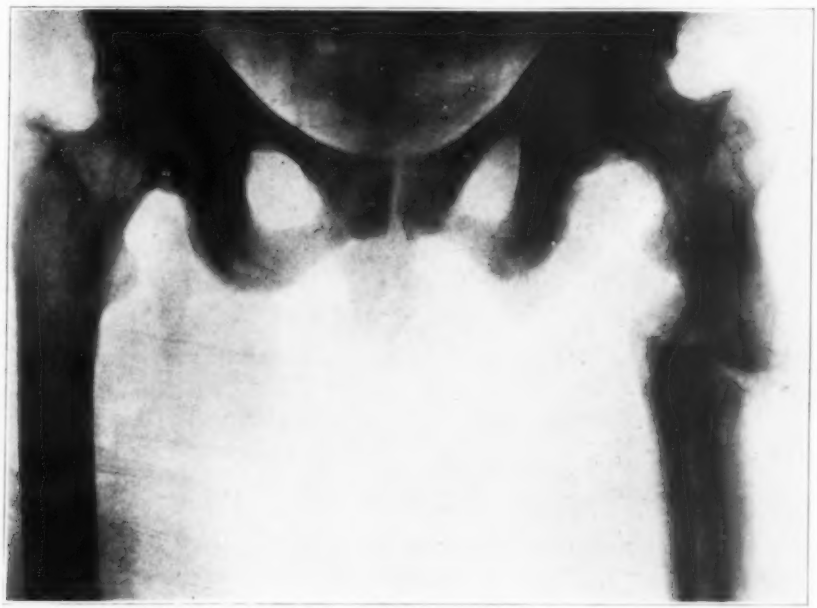

FIG. 4

Roentgenogram, taken August 1, 1933, showing fracture united with profuse callus formation. The callus is almost as completely ossified as the adjacent bone.

COLT, G. H., AND LYALL, A.: A Case of Osteitis Deformans Treated with Parathormone. British Med. J., II, 10, 1933.

JEROME, J. T., AND COMPERE, E. L.: The Pathological and Biochemical Changes in Paget's Disease. Illinois Med. J., LXIV, 449, 1933.

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AN ATTACHMENT FOR FRACTURE TABLES

Designed to Facilitate the Application of Plaster Casts to Maintain Hyperextension of the Spine

BY W. V. NEWMAN, M.D., LITTLE ROCK, ARKANSAS

From the Department of Orthopaedic Surgery, University of Illinois, College of Medicine, Chicago

An attachment for the Albee and Hawley fracture tables has been designed which eliminates the use of bars, slings, and other pieces of apparatus interfering with the application of body casts as well as those which include the head and extremities and which produce hyperextension of the spine.

Attachment for the Albee Table

Two scapular rests are fashioned, as shown in Figure 1, and are made interchangeable with the foot rests upon the traction screws. A piece of steel, six inches by one inch, is used. One end is flattened to form a disc, two and one-half inches in diameter and one-eighth of an inch thick, which tapers into a shaft, five and one-half inches by one inch. A hole is drilled in the shaft, two and one-half inches deep and five-eighths of an inch in diameter. A set screw is placed a quarter of an inch from the end.

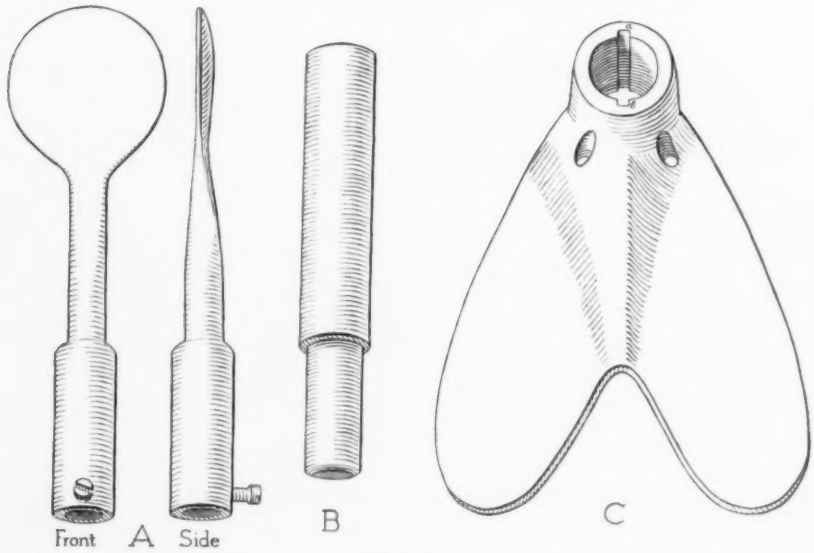

FIG. 1

Parts of attachment:
A. Front and side views of scapular rests.
B. Post from lower end of table, fitted with sleeve.
C. Sacral rest, showing original keyway (*a*) and new keyway (*b*).

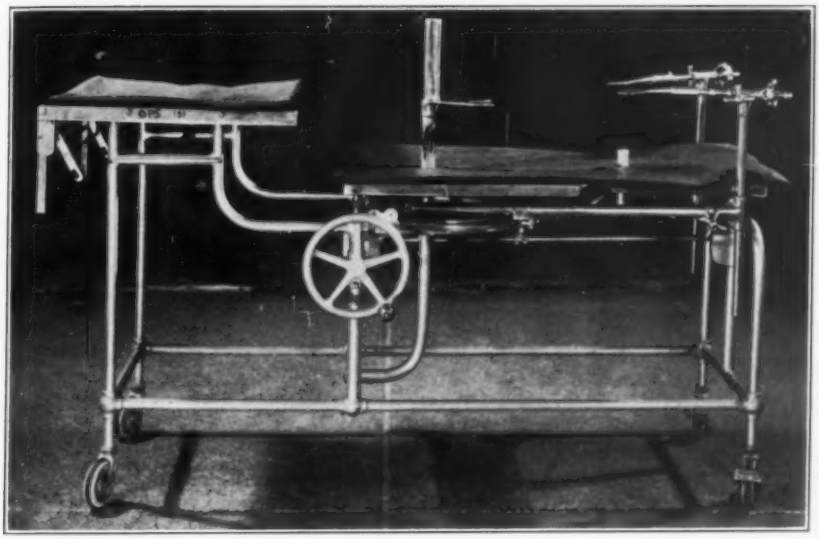

FIG. 2

Albee table with scapular rests in position. Post at lower end of table removed and sacral rest reversed.

Attachment for the Hawley Table

This attachment is made interchangeable with the traction screws and differs slightly from that devised for the Albee table. The shaft is made six inches longer with a keyway running its entire length and threaded with V-type threads, twelve to the inch.

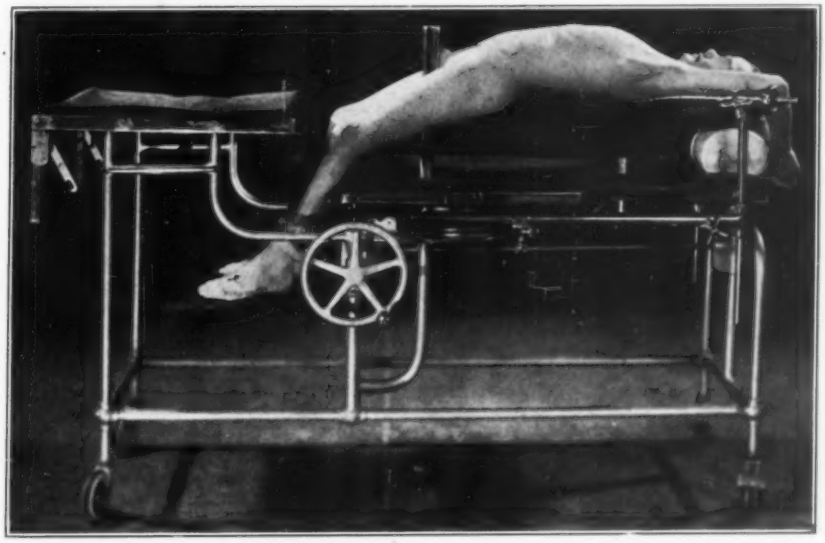

FIG. 3

Patient in supine position, ready for application of cast.

FIG. 4

Patient in prone position upon the Hawley table, ready for application of cast.

Application

The patient is placed upon the table with the head at the foot end. A pillow or sand-bag is used to maintain hyperextension until the necessary adjustments are made. The perineal posts are then inserted. With the patient's arms abducted and externally rotated, the scapular rests are manipulated to a position directly beneath the scapulae. The legs are dropped either over the sides of the table or inside beneath the back rest. The lower end of the table is now depressed and a small pillow or roll of stockinet is placed beneath the head. The patient now rests securely and comfortably in an hyperextended position. When the cast is hard, the scapular rests are easily withdrawn through the axilla by swinging the traction arms outward.

In order to increase dorsal extension, the scapular rests are raised above the level of the table top. Should more lumbar extension be desired, the scapular rests may be lowered.

This attachment may be used with the patient lying face downward upon the table. One or two firm pillows are placed upon the upper portion of the table top and the sacral rest to support the thighs comfortably and to prevent hyperextension of the legs. The perineal post is inserted to keep the body from sliding backward. With the patient's arms extended, the scapular rests are placed in a line parallel with the sides of the table and beneath the heads of the humeri. The table top is depressed and the weight of the body hyperextends the spine.

The advantages of this device over the ones now in general use are:

1. Elimination of pieces of apparatus which prevent adequate casting and proper molding of the cast to the parts.
2. Increased comfort for the patient.

The author wishes to acknowledge the mechanical assistance of Mr. J. J. Molloy, of the University of Illinois, College of Medicine.

News Notes

The Annual Meeting of the **British Orthopaedic Association** will be held in London on November 2 and 3. A report of the Meeting will appear in the next issue of *The Journal*.

The meeting of the **Deutsche Gesellschaft für Unfallheilkunde, Versicherungs- und Versorgungsmedizin** will be held in Würzburg on October 12 and 13, immediately following the Congress of the Deutsche Orthopädische Gesellschaft. The principal topics for discussion are: (1) Concussion of the Brain and Injuries to the Brain; (2) The Sensitive Knee; and (3) Results of Accidents and Their True Significance.

Announcement has been made by the **Istituto Ortopedico Rizzoli** in Bologna, Italy, of the competition for the prize Umberto I. This prize of 3,500 lire will be awarded for "the best orthopaedic work or invention", the decision to be made by the Provincial Council of Bologna. Doctors of all countries, as well as Italian doctors, may participate in this competition, which will close on December 31, 1934. Application for the competition should be made to the President of the Istituto Ortopedico Rizzoli, Bologna, who will furnish the rules upon request.

The Annual Meeting of the **Czechoslovakian Orthopaedic Society** was held in Prague on June 23 and 24, under the presidency of Prof. Jan Zahradníček. The principal subjects were "Internal Derangements of the Knee", the discussion opened by Prof. Bedřich Frejka, of Brno, and "Anomalies of the Spine", the discussion led by Prof. Jan Zahradníček, of Prague. Prof. Bedřich Frejka was elected President for the coming year. The Congress of 1935 will meet in Brno late in September. The main question for discussion is "Deformities, Chronic Diseases and the Sequelae of Fractures of the Spine (Excluding Scoliosis and Tuberculosis)". The principal speakers will be, for the Yugoslavian Society, Dr. Gradjěvić and, for the Czechoslovakian Society, Prof. Bedřich Frejka.

THOMAS BOYKIN CLEGG

Word has been received at *The Journal* office of the death of Dr. Thomas Boykin Clegg, of the Shriners' Hospital, Greenville, South Carolina, on July 23, 1934.

Dr. Thomas Boykin Clegg was born December 2, 1896, in Social Circle, Georgia. After receiving his preliminary education locally, he received his academic and medical training at Emory University, graduating in Medicine in 1925.

After spending two years as Resident at the Piedmont Sanitarium, where he was associated with Dr. Michael Hoke and Dr. Lawson Thornton, he became Associate Surgeon of the Shriners' Hospital, Greenville, South Carolina, where he served most efficiently and faithfully until the time of his death.

Although Dr. Clegg was of a retiring personality and was not yet widely known in orthopaedic circles, his sterling qualities were thoroughly appreciated, particularly by his professional friends who realized that he had a brilliant future in store for him. He was a tireless and efficient worker. In addition to his work at the Shriners' Hospital, he carried on several orthopaedic clinics in hospitals in nearby cities, where his absence will be keenly felt.

Current Literature

RADIOLOGY OF BONES AND JOINTS. By James F. Brailsford, M.D., M.R.C.S. Baltimore, William Wood & Company, 1934. $9.00.

The author stresses the importance of frequent roentgenographic examination, which is especially valuable in studying the progress and the changes in bone disorders. He shows typical illustrations of the most important forms of lesions and those most frequently encountered, and gives excellent descriptions of the roentgenographic findings, with the directions for their interpretation.

The arrangement of the subjects is convenient, both for reference and for the comparison of similar affections. The first and second chapters of Part I are devoted to the subjects which cannot be well classified, but which are related to the general bone conditions and affections distributed throughout the body. In the remaining chapters of Part I, the grouping is regional and structural,—such as the lower ends of the radius and ulna, the carpus, the foot, the shafts of bone, and the different joints. The various affections as they appear in these locations are considered in detail. The characteristic roentgenographic findings indicative of the various disorders (fractures are not included in this work) are described and illustrated. The author has made a special feature of the description of evidence given by x-rays—the appearance of various conditions which present similar signs—and of the differential diagnosis, which are definite aids in these times when the rapid advancement in roentgenographic equipment and technique is producing finer distinctions in the roentgenographic appearance and making the interpretation more difficult.

In Part II, there is an excellent discussion on the subject of bone changes in systemic and localized diseases, including both benign and malignant bone tumors. This portion is not confined to the roentgenographic appearance alone, but the history, pathology, and the clinical signs in conjunction with the roentgenology are presented in a way to make more evident the special structural changes shown by the roentgenogram.

This volume has a much more evident clinical bearing than has the average book dealing with the subject of roentgenology, and will be of value especially in the differentiation of many conditions which present a similar roentgenographic appearance. The author has given the result of a long and extensive experience with this subject and his opinions will be found most valuable.

FUSS UND BEIN, IHRE ERKRANKUNGEN UND DEREN BEHANDLUNG (Diseases of the Foot and Lower Extremity and Their Treatment). By Prof. Dr. Med. Georg Hohmann. Ed. 2. Munich, J. F. Bergmann, 1934. 24 marks.

A monograph which for a decade has been authoritative on statics and abnormalities of the lower extremity, has been largely rewritten and expanded to twice its size. The illustrations which were mostly collected at the back of the early edition have been in part replaced, more than doubled in number, and rearranged throughout the book to accompany the appropriate text. The volume does not pretend to include all subjects. Paralyses, tuberculosis, and club-foot are not discussed. Other common subjects are only briefly mentioned. Many conditions which have been described only in the recent literature, or which have been omitted from text-books for lack of space, are fully presented. For its wealth of original material this monograph deserves mention among the "one man" books. Most valuable are the contributions on the treatment of major and minor foot ailments. The writer's osteotomy for hallux valgus is already well known, but the removal of nipped fat pads in the ankle is new.

The borrowed cuts and the summaries of the German orthopaedic literature establish its value as a reference book. This value is enhanced by the appended bibliography which is classified by subjects.

Among the new chapters may be noted those on malformations of the foot and toes, infectious and degenerative diseases, lesions of the calcaneum, and growth disturbances of the ankle. Some of Böhm's new work on congenital deformities and an abstract of Max Lange's monograph on "Muskelhärten" are included.

Although written for the general practitioner as well as the orthopaedic surgeon, the book will be most appreciated by the latter. One who knows the first edition will be most anxious to acquire the second.

ORTHOPEDIC SURGERY FOR NURSES. By Philip Lewin. Ed. 2. Philadelphia, W. B. Saunders Company, 1934. $3.25.

That this manual has met a real demand is attested by the fact that the first edition has had two reprintings since its original appearance in 1928 and that the publishers have authorized a complete resetting and revision in 1934. This may be regarded, not only as testimony to the excellence of the work itself, but also as evidence of the increase of interest in orthopaedic surgery among teachers of nursing and nurses themselves.

From a mechanical standpoint, the book leaves little to be desired. The illustrations are clear and, almost without exception, truly explanatory. While the subject matter has been treated throughout in a compendious manner, the extent of the ground which has been covered is quite remarkable. In fact, the book might almost be designated as encyclopaedic. One might well wonder whether in any nursing school, save that of an orthopaedic hospital, it is possible that pupils are carried through a course of training and study in this special field so all embracing as this. The question may indeed be asked whether they should be. It seems perfectly fair to say that in no medical school of this country is the undergraduate student given a training in orthopaedic surgery as extensive as would be implied by the contents of this volume. A search for omissions of importance in this text will meet with little reward.

To the orthopaedic surgeon himself, this small book may prove surprising in the wide field which it covers, and he will find matters treated and designations mentioned which will not be found in any text-book on Orthopaedic Surgery at present offered to him. The author is to be congratulated upon the thoroughness and the excellence of his work. He will be found to have given due credit to all those who have contributed to the knowledge and resources of orthopaedic surgery; he has especially dedicated the work to Dr. John Lincoln Porter.

HANDBUCH DER GESAMTEN UNFALLHEILKUNDE. Herausgegeben von Fritz König und Georg Magnus. IV. Band. Stuttgart, Ferdinand Enke, 1934. Lief. 1, 11.20 marks; Lief. 2, 14 marks; Lief. 3, 12 marks; Lief. 4, 9 marks; Lief. 5, 11 marks; Lief. 6, 11.80 marks.

In this, the fourth and last volume of the series, the authors continue to discuss the relationship of industrial injury to various diseases. The subjects considered are: ailments of the spine, the central and peripheral nervous systems, the head, neck, chest, abdomen, pelvic diseases, and diseases of the skin. Each organ or structure, as it may be affected by injury or disease resulting from industrial activity, receives attention.

This work should be of great value to the surgeon who is frequently called upon to determine the relationship of the patient's illness to his industrial activities.

THE OPERATIVE TREATMENT OF COLLUM FEMORIS FRACTURES. By Sven Johansson. Copenhagen, Levin & Munksgaard, 1934.

The author has presented in an excellent little monograph his method and results of treatment of this injury. He has preceded the portion that describes his own method by a general consideration of the condition,—the types of fractures, the methods of examination and of taking the x-rays, treatment, sequelae, and the secondary changes after heal-

ing. He has also given a résumé of other methods of treatment before considering his own.

The author's method is a modification of the Smith-Petersen method; he uses the same nail, but he operates without exposure of the fracture and obtains an extra-articular osteosynthesis with the same peg. The author's method consists, first, of the insertion of a steel wire into the neck and head, the position of which is verified by the x-ray. The nail is especially constructed so that it can be threaded to this wire, which then serves as a guide when the nail is inserted. The author has constructed a special alignment apparatus which is connected with the operating table and which adds to the ease and accuracy of introducing the wire.

All the steps in the treatment are checked by the x-ray. No plaster extension is used, but the Braun splint is frequently applied; sometimes sand bags only are used. Early motion is instituted within ten days. The patient is usually kept in bed for a month and early ambulatory treatment is allowed.

Fifty cases are fully reported, each with excellent roentgenograms.

Die Behandlung der Knochenbrüche durch den Praktischen Arzt. By Geh. Hofrat Prof. Dr. Fritz Lange. Munich, J. F. Lehmanns, 1934. 4.20 marks.

This monograph, the second revised edition, consists of 142 pages and contains 116 illustrations. It is intended for the practitioner as a guide in the treatment of fractures. For this reason, the methods of treatment described by the author are, to a large extent, carried out by the use of improvised appliances which can be easily constructed and efficiently applied. The author does not fail to emphasize the difficulties encountered in different injuries and demonstrates how they may be overcome by efficient use of home remedies.

This work would have no great appeal for the surgeon who has access to hospital facilities and modern equipment, but will be found useful to the practitioner who is not so fortunately situated.

The Spastic Child. By Marguerite K. Fischel. St. Louis, The C. V. Mosby Company, 1934. $1.50.

This book is an interesting report by a mother of her years of experience with physiotherapy in two cases of severe Little's disease in her own children. Dr. Allison was sufficiently impressed with the results of her work to advise her to report her methods and experience.

The main issue in this account is not so much the special form of physiotherapy used as the method of its application and the intelligent and conscientious persistence which always accompanied its use. The book clearly illustrates the fact, far too little recognized, that the way in which these therapies are given, more than the special form of therapy used, is the essential element that leads to success; also that the benefit derived from these treatments may be expected to continue for many years.

The work should be a guide and a stimulus to those who come in contact with this type of spastic disorder, especially to mothers and physiotherapists.

On Defects in the Bone-Graft after Albee's Operation for Tuberculous Spondylitis. By G. Odelberg-Johnson. Translated by Carl Westman. Copenhagen, Levin & Munksgaard, 1934.

In this 200-page monograph are recorded the results of the author's investigation of 278 cases in which the Albee bone-graft operation had been performed. This study was carried on at the Apelviken Coast Sanatorium and in the Orthopaedic Clinic of the Caroline Institute, Stockholm, during the period 1931 to 1934.

The author's clinical material comprises thirty-seven patients in whom gaps had

occurred in the grafts. Thirty-six of these patients were operated on at the Coast Sanatorium at Apelviken and one had had the Albee operation performed elsewhere, but was subsequently under treatment at this Sanatorium. Of these thirty-seven patients, fifteen were children under seventeen years and twenty-two were adults. A detailed case history of each patient is included.

The author presents his findings from a histological study of grafts recovered at varying periods after operation. He shows conclusively that the bone graft dies and is slowly replaced by bone cells from the split spinous processes and the transplanted periosteum.

Five specimens were recovered from grafts that had been broken from two weeks to fifteen months after the operation, and the area of the graft defect was studied microscopically. The gaps between the parted ends are shown to have filled with cartilage which is converted into endochondral bone. At times the gap is filled and the ends may unite; at other times, a pseudarthrosis results. The author believes that the gaps are caused by acute and insidious fractures of a largely necrotic graft.

When there is a recurrence of the knuckle, the whole object of the graft is lost. In cases where the vertebral lesion is localized, the graft defect shows a fairly good tendency to repair and is of little importance. When the disease is progressing and extending to involve more vertebrae, the fixation of a graft has little effect upon the progress of the disease. The graft defects which occur in these progressive cases may consolidate later when the disease becomes less active and begins to heal. When the defects appear between normal vertebrae, above or below the diseased area and late in the disease, they are of little importance,—they do not unite, but form a pseudarthrosis. The author feels that gaps are of far less importance than an extensive absorption of the graft.

Patients should not be kept in bed for a long period after the operation,—seven or eight weeks is usually sufficient in uncomplicated cases. A corset is then worn for from twelve to eighteen months.

Die Operation der Skoliose (Operation for Scoliosis). Johanna Müller. Inaug.-Diss., Univ. Leipzig, 1933.

This is a thorough review of the literature on the operative treatment of scoliosis. No original studies were made by the author.

Operations on soft tissues have consisted almost entirely of myotomies in various localities, to facilitate correction of the deformity. The most valuable procedure is, of course, some form of stabilization of the spine.

The writer deplores the lack of sufficient control studies and also the lack of satisfactory studies of end results. However, as treatment by conservative methods has not produced any satisfactory results, operative therapy must be further considered as a means of solving the problems.—*R. J. Dittrich, M.D., Fort Scott, Kansas.*

The Journal wishes to acknowledge the receipt of the following publications sent to the Editorial Department:

Boletines de la Sociedad de Cirugía de Rosario (Argentina), I, Núm. 4, 1934.

Boletines y Trabajos de la Sociedad de Cirugía de Buenos Aires, XVIII, Nos. 1–8, 1934.

Bulletin of the National Tuberculosis Association (New York), XX, No. 7, 1934.

The Indian Medical Journal (Calcutta), XXVIII, No. 3, 1934.

Hospital for Joint Diseases of the City of New York, Twenty-Seventh Annual Report, for the Year 1933. New York, 1934.

The Johns Hopkins University, School of Hygiene and Public Health, Announcements for 1934–1935. Baltimore, 1934.

Medico-Surgical Suggestions (Madras, India), III, Nos. 4, 5, 1934.

La Tribuna Médica (Havana), VIII, Nos. 218–223, 1934.

Programm des 53. Fortbildungskursus der Wiener Medizinischen Fakultät (Vienna), 1934.

Verzeichnis der Ärztekurse im Studienjahre 1934/35, das Kursbüro der Wiener Medizinischen Fakultät (Vienna), 1934.

STUDIEN ÜBER KNOCHENIMPLANTATION UND KNOCHENNEUBILDUNG, IMPLANTATION VON "OS PURUM" SOWIE TRANSPLANTATION VON "OS NOVUM" (Studies of Bone Implantation, New Bone Formation, Implantation of "Os Purum", and Transplantation of "Os Novum"). Svante Orell. *Acta Chir. Scandinavica*, LXXIV, Supplementum XXXI, 1934.

In studying the fate of transplanted bone of various kinds, the writer arranged unusual experimental studies, using human beings as laboratory animals. Starting eight years ago with the simple experiment of including small pieces of autogenous and heterogenous bone in the tibial defect or under the periosteum of the tibia after the removal of a bone graft, he went on to more complicated procedures. Prepared heterogenous bone, called by the writer *os purum*, was implanted subperiosteally. After several months, new bone was found to have formed about the prepared bone. This was called *os novum*. The fate of various types of bone under various conditions was studied grossly and microscopically in great detail.

A second part deals primarily with the clinical use of transplants of autogenous bone and *os novum*, and implants of *os purum*. Representative uses of the different types of bone in different joints are illustrated. Special emphasis is laid upon internal fixation of the spine. Here autogenous bone, or a combination of *os purum* with *os novum*, was found to be satisfactory, while *os purum* alone was absorbed. *Os purum* is useful as a mechanical fixation and in stimulating the host to bone formation.

The writer is preparing a third part which is to deal with the technique of bone transplantation.—*W. P. Blount, M.D., Milwaukee, Wisconsin.*

GIANT CELL TUMOR OF THE SPINE. Henry Milch. *Am. J. Cancer*, XXI, 363, June 1934.

The author has reviewed the literature on giant-cell tumor of the spine and finds that the condition is comparatively rare.

He reports a case of a sixteen-year-old boy who had had symptoms for about six months referable to his cervical spine and consisting chiefly of pain and limitation of motion. On examination, a tumor was felt in the region of the third cervical spine, roentgenographic examination of which suggested a giant-cell tumor. At operation the spinous process of the vertebra and the posterior portions of the adjacent laminae were removed. Microscopic examination confirmed the diagnosis of giant-cell tumor. Following operation, the patient was treated over this area with radium packs, receiving a total dose of 22,250 milligram hours. Roentgenographic examination a year later showed no evidence of disease and an almost complete regeneration of the neural arch.

The author suggests that such cases be treated by radiation, either alone or combined with surgery.—*Grantley W. Taylor, M.D., Boston, Massachusetts.*

OSTEITIS FIBROSA OF RECKLINGHAUSEN, HETEROTOPIC PARATHYROID ADENOMA, METASTASES OF A BENIGN ADENOMATOUS STRUMA AND ADENOMA OF THE LEFT ADRENAL IN THE SAME PATIENT. Hilding Bergstrand. *Am. J. Cancer*, XXI, 581, July 1934.

The author reports this case in detail with roentgenograms, photographs, and photomicrographs. The presence of adenomata in three internal secretory glands points to an embryonal disturbance as the basis of them all. Metastases of a thyroid adenoma are rare. In this case they were present in the lungs and in the humerus, and showed the characteristic microscopic picture of struma colloides. The author states that the essence

of Recklinghausen's disease of bone appears to be a general osteolysis around the bone corpuscles. The other changes—such as new bone formation, cysts, and giant-cell tumors—are secondary and are not essential to the diagnosis.—*Grantley W. Taylor, M.D., Boston, Massachusetts.*

LIPOID TUMORS. Charles F. Geschickter. *Am. J. Cancer*, XXI, 617, July 1934.

The author presents a brief monograph on lipoid tumors, based on a study of the available material on file at the Johns Hopkins Hospital, and well illustrated by photographs, roentgenograms, and photomicrographs. He recognizes two major groups of lipoid tumors,—the first comprising true neoplasms; and the second, the xanthomatous tumors with lipoid phagocytosis, which are called granulomata.

The true lipomata are of orthopaedic interest primarily because they may involve skeletal structures. In the author's series of 460 cases of benign lipoma, the joints were involved in seven cases and the bones in two. Recurrent lipomata and liposarcomata may involve the extremities and thus give rise to orthopaedic problems.

Among the xanthomatous tumors presenting localized lipoid phagocytosis of the author's series, there were seven instances of xanthoma of the joints and fifty-five instances of so called giant-cell tumor of the tendon sheath. The latter are usually small, solitary, benign tumors occurring in the region of the sesamoid bones in adults. Ewing is quoted as believing that they are synovial tumors. The author considers them giant-cell tumors complicated by lipoid phagocytosis.

The author recognizes a symptomatic form of xanthomatosis, which complicates diabetes, nephrosis, and some other systemic conditions; and a primary form, which includes the syndromes known as Schüller-Christian disease, Gaucher's disease, and Niemann-Pick disease.

Very constant features of Schüller-Christian disease are the large defects in the membranous bones of the skull. The flat bones of the pelvis are sometimes affected, and, in the author's series, the long bones were also usually involved. The roentgenographic appearance of the long-bone involvement in one instance suggested osteomyelitis, for which resection was carried out. Microscopically, the constant finding is hyperplasia of the bone marrow, characterized by macrophages, eosinophiles, plasma cells, and lymphocytes.

Gaucher's disease involves chiefly the spleen and the long bones of children. The femora present a peculiar flask-like expansion, with small areas of rarefaction which may be mistaken for osteomyelitis.

The author concludes with a brief discussion of the histogenesis and etiology of lipoid tumors.—*Grantley W. Taylor, M.D., Boston, Massachusetts.*

OSTEITIS TUBERCULOSA MULTIPLEX CYSTICA OF FIBULA AND TIBIA. Samuel Sanes and Warren S. Smith. *J. Am. Med. Assn.*, CII, 1206, April 14, 1934.

Following its introduction by Jüngling in 1920, the term "osteitis tuberculosa multiplex cystica" was applied to cyst-like degeneration of the bones without joint involvement, characterized by gradual onset and mild pain and swelling of the affected parts, distinctive x-ray picture, and a chronic, benign course. Not infrequently associated with it were lupus pernio and Boeck's sarcoid. Histologically, the bone showed epithelioid and giant-cell tubercles with little or no caseation. Tubercle bacilli were rarely found; guinea-pig inoculation occasionally gave positive results.

Van Alstyne and Gowen, in reviewing the literature, noted that the small bones of the hands and feet were usually the restricted sites. They, however, reported the first authentic case appearing in the long bones, that of a white man, aged thirty-two years, who presented destructive changes in the left radius and ulna and in both humeri. Tuberculous etiology was established by histological and bacterioscopic studies and by guinea-pig inoculation.

Because of its rarity, a case of osteitis tuberculosa multiplex cystica of the tibia and fibula is reported.

An American woman, aged fifty-six years, was admitted to the Service of Dr. W. W. Plummer, complaining of pain and swelling of both lower legs of three months' duration. Several of her immediate family had died of tuberculosis. Slight pain and swelling was found over the lower end of the right fibula; in the right ankle motion was free and painless. Roentgenograms showed cyst-like areas of decreased density in the left fibula and right tibia.

At operation a small area of destruction was found in the lower end of the right fibula, filled with an abundance of red, granulated tissue. The soft tissue appeared normal. The histological diagnosis was tuberculous osteomyelitis, with inflammatory osteoporosis. Two roentgen-ray treatments were given after operation and the incision healed clean and dry.

Subsequently an incision was made over the left internal malleolus and a like area was encountered.

An analysis of its anatomical and pathological features suggests that the condition might more accurately be designated as "osteomyelitis tuberculosa multiplex cystoides". The primary lesion is a tuberculous osteomyelitis. From a focus somewhere in the body infecting organisms are carried by the blood stream to the bone marrow.

Because of its benign course, no plan of treatment has been recommended with the exception of immobilization and symptomatic measures. It is too early to evaluate the results of the surgical and roentgen-ray therapy in the case reported.—*W. B. Carrell, M.D., Dallas, Texas.*

Painful Heels Among Children (Apophysitis). Henry W. Meyerding and Walter G. Stuck. *J. Am. Med. Assn.*, CII, 1658, May 19, 1934.

Since the discovery of roentgen rays, a number of clinical syndromes have been shown to be specific diseases. The pathological physiology of the bone as shown by the roentgenograms has given an understanding of the disease process in Osgood-Schlatter disease, Köhler's disease, Legg-Perthes disease, Buchmann's disease, and Freiberg's disease. The roentgenogram has made it apparent that there are marked similarities in the general pattern in these diseases.

A seemingly uncommon epiphyseal involvement is calcaneal apophysitis, as to date only forty cases have been reported in the literature. Only twenty-one cases have been seen in The Mayo Clinic,—in two girls and nineteen boys. The age range was from seven and one-half to seventeen years; the average age was ten and two-tenths years. There was bilateral involvement in fourteen cases.

The apophysis is both a pressure and a traction epiphysis. It is subject to direct trauma as well as to a constant lateral pull from the attached muscles.

The condition is seen most commonly in vigorous boys between the ages of eight and twelve. A history of trauma may be obtained. The condition is usually bilateral. The first symptom is slight pain in the heel, and the patient limps. On examination, the heels are found to be tender posteriorly and there may be some lateral thickening at the insertion of the tendo achillis. Often the children are overweight or present some gross evidence of glandular disturbance.

The characteristic feature is the change noted on roentgenographic examination. In the lateral view, the apophysis is seen to be fluffy, moth-eaten, somewhat flattened, or partially fragmented, acording to the stage of the disease. All of the pathological changes are dependent directly or indirectly on disturbance in circulation. Since the apophysis appears late in the tenth year and unites at the age of seventeen, the disease is confined to this short period.

Treatment is palliative and extremely simple and consists of the application of local heat and massage during the acute stage. The heels are elevated to relieve the tension on the gastrocnemius muscle. In severe and resistant cases, immobilization in plaster may be necessary.

It is common for such a process to take place in the heels of healthy children, but the symptoms are often so mild that no roentgenographic examination is made; hence, the diagnosis is not absolute. Due to the above facts, it is concluded that the disease is not an unusual one, but passes undiagnosed because of the mildness of the symptoms and because roentgenograms are not taken.—*Ike Kendrick, M.D., Dallas, Texas.*

Dislocation of the Shoulder Accompanied by Fracture of the Greater Tuberosity and Complicated by Spinatus Tendon Injury. Paul W. Greeley and Paul B. Magnuson. *J. Am. Med. Assn.*, CII, 1835, June 2, 1934.

In the experience of the authors, fracture of the greater tuberosity of the humerus, associated with dislocation of the shoulder, is relatively rare. In reviewing the large series of cases reported in the literature, this finding has been borne out.

Complicating this type of fracture dislocation of the shoulder is injury to one or both of the spinatus tendons. The symptoms are those of dislocation of the shoulder, with marked tenderness over the greater tuberosity, which is not found in simple dislocation. In the history, the patient will always mention a direct blow against the shoulder at the time of the injury.

The dislocation is reduced by the Kocher method, which usually replaces the greater tuberosity. Open operation to replace the tuberosity is rarely ever necessary. Fixation in abduction and external rotation is the position of choice and is maintained for from three to four weeks. Physiotherapy is then instituted.

Treatment of the tendon injury is more complicated. In the case of a partial rupture, the position of abduction and external rotation promotes repair. In case of doubt, exploration of the tendons is justified. In the case of a complete rupture, the tendon should be anchored to the greater tuberosity or to the subscapularis tendon. Fixation in these cases should be maintained for six weeks; the arm should then be placed in a sling for several days and physiotherapy should be begun.

In cases in which the operation is done early perfectly useful joints result. Old cases, presenting muscle atrophy and tendon shortening, may result less favorably, with limitation of motion and pain.

Five cases are reported, one of which was treated by open operation. Good results were obtained in all cases by following the treatment outlined above.—*Ike Kendrick, M.D., Dallas, Texas.*

Acute Anterior Poliomyelitis in Philadelphia. A Comparative Study of the 1916 and 1932 Epidemics. J. Norman Henry and George E. Johnson. *J. Am. Med. Assn.*, CIII, 95, July 14, 1934.

In the 1916 epidemic, there were 1006 cases, with 307 deaths,—a death rate of 30.4 per cent. In the 1932 epidemic, there were 728 cases, with 84 deaths,—a death rate of 11.5 per cent. These death rates are hardly comparable as, in the 1916 epidemic, paralysis was the diagnostic criterion, while, in the 1932 epidemic, many cases in the preparalytic stage were included. In 1932, the disease was less severe and resulted in less permanent crippling.

From a seasonal standpoint, the peak in both epidemics was reached in the fourth week in August.

Serum from convalescent patients was collected and pooled. This serum was used both for prophylaxis and for treatment of cases. In fourteen hospitals, 2,255 children were immunized; one hospital immunized 1,341 children, among whom three cases of poliomyelitis developed.

The hospital facilities of the city were organized and the city divided into districts, each district being placed under the charge of a diagnostician. In the 1932 epidemic, a greater number of the cases were hospitalized and there was a fall in the death rate in these cases. Hospitalization, cooperation by the medical profession, and quarantine of homes constituted the main control measures.

In the 1932 epidemic, many cases were diagnosed in the preparalytic stage. In a study of 605 follow-up cases, 43.8 per cent. were classified as normal; 14.4 per cent., as good; 13.9 per cent., as fair; 9.3 per cent., as poor; 3.4 per cent., as showing a trace of paralysis; 2 per cent., as totally paralyzed; and 13.2 per cent. died. The end results seemed definitely better than in 1916.

The group most susceptible in both epidemics was the group ranging in age from five to ten years, with the higher age groups involved to a greater degree in the 1932 outbreak. In 1932, 57 per cent. of the patients and 45 per cent. of the deaths were in the age group under five years; whereas, in 1916, 88 per cent. of the patients and 85.4 per cent. of the deaths were in this group.

No conclusive evidence is offered with regard to the value of passive immunization by the use of whole blood or serum.

The use of immune serum for treatment in the early preparalytic cases seems justified by the end results obtained in a small series of cases and controls. The dearth of true secondary cases in families, hospitals, and institutions serves to emphasize the fact that infection by direct contact with clinical cases is not common. Human carriers apparently constitute the reservoir for the virus.

To control such an epidemic and to insure the best care and follow-up, all available agencies must be solicited.—*W. B. Carrell, M.D., Dallas, Texas.*

Late Results of the Lavall Operation and the Bone-Peg-Insertion Operation. N. I. Blinov. *Orthopaedia i Travmatologia*, IV, 1, 1933.

A thorough study of the Russian and foreign literature shows that the late results of these operations in tuberculous joints are less favorable than has been reported. The personal observation of the author prompts the following conclusions:

The autoplastic transplantation of a bone peg in tuberculous joints does not alter the development of the disease. In the majority of cases, a temporary subjective improvement has been noticed. The presence of the bone peg does not improve the atrophy of bone. The introduction of a bone peg can be justified in old tuberculous processes, but in these cases there are better methods of producing an ankylosis of the joints. *Emanuel Kaplan, M.D., New York, N. Y.*

Late Results After Hahn's Operation. A. Fedorovsky. *Orthopaedia i Travmatologia*, IV, 57, 1933.

A case is described in which a complete resection of the metaphysis of the tibia was done because of an extensive osteomyelitis of this bone. Eight months after this operation, a transplantation of the fibula, freed by osteotomy at the proximal end, was performed.

The free proximal end of the fibula was grafted into the proximal diaphysis of the tibia. Three and a half years after the last operation, the x-ray showed a marked widening of the fibula, complete union of the fibula and tibia at the proximal end, and lateral fusion of the distal diaphysis of the tibia with the medial surface of the distal end of the fibula. There was a shortening of three centimeters. The function was excellent.—*Emanual Kaplan, M.D., New York, N. Y.*

Congenital Malformation of the Spine in Situs Inversus Viscerum Totalis. A. Marinitsch. *Orthopaedia i Travmatologia*, IV, 62, 1933.

The author describes a patient in whom a complete situs inversus viscerum was coexistent with a deformity of the spine. The lower dorsal spine showed a left scoliosis with a wedge deformity of the tenth and eleventh vertebrae and between these a hemivertebra, with a supernumerary rib connected with it. There was also a spina bifida, involving the first and second sacral vertebrae. The author could not find a similar case in

the available literature. He considers the simultaneous existence of these deformities as further proof that the situs inversus viscerum is an anomaly due to a defect in the germ layers.—*Emanuel Kaplan, M. D., New York, N. Y.*

THE MECHANISM OF DISPLACEMENT OF THE MENISCI IN THE HUMAN BODY. V. Tarkhanov. *Orthopaedia i Travmatologia*, VII, No. 2, p. 28, 1933.

A thorough anatomical study of the knee joint demonstrates that the displacement of the menisci of the knee is not due to a purely mechanical process. The relation of the posterior horn of the medial meniscus to the semimembranosus and gastrocnemius muscles and of the posterior horn of the lateral meniscus to the popliteus muscle, regulates the backward motion of the menisci. The relation of the anterior horns of both menisci to the patella, and through it to the quadriceps femoris, controls the anterior motion. The author thus comes to the conclusion that the anterior and posterior displacements of the menisci are conditioned by a neuromuscular mechanism of the muscles surrounding the knee.—*Emanuel Kaplan, M.D., New York, N. Y.*

UN SIGNE PATHOGNOMONIQUE DE FRACTURE DE L'OMOPLATE (A Pathognomonic Sign of Fracture of the Scapula). Antonio Comolli. *Presse Méd.*, XLII, 1119, 1934.

In 1932 the author described a sign which he had observed in several cases of fracture of the scapula. This consists of "the appearance in the scapular region, after a trauma, of a triangular tumefaction, which almost reproduces the outline of the body of the scapula." The swelling, best seen in a strong light with the patient erect and the arms at the side, may appear within several hours after the fracture and gradually disappears during the following eight or ten days. The occurrence of this phenomenon depends upon two factors: injury to the large vessels forming the scapular plexus; and the integrity of the fascia covering the subscapularis, the supraspinatus, and the infraspinatus muscles. In the latter event, hemorrhage from the torn vessels distends these three spaces, so that the scapula as a whole is elevated from the chest and becomes outlined beneath the skin. In some cases the distention is so great that a definite furrow can be seen between the supraspinatus and the infraspinatus fossae at the line of attachment of the fascia along the spine of the scapula.

When present, the sign is pathognomonic of fracture of the body of the scapula. Fractures of the inferior or medial angles, or fractures of the coracoid or acromion processes, lead at most to localized swellings, but never to the diffuse cushion-like triangular tumefaction characteristic of fractures of the body. However, the absence of this sign does not exclude the existence of fracture of the body of the scapula. The author calls attention to the fact that in certain cases where injury to the large vessels has not occurred, or has been minimal, the swelling will not appear. On the other hand, in those cases in which extensive vascular injury must be predicated, because of the extent of the fracture, the absence of the sign must be explained as due to laceration of the fascia overlying the muscles and the consequent destruction of the fascial cells.—*Henry Milch, M.D., New York, N. Y.*

LA SPLÉNOMÉGALIE ARTHROPATHISANTE (Splenomegalic Arthropathy). P. Alessandrini. *Presse Méd.*, XLII, 1190, 1934.

The author reports in detail two cases which were characterized by splenomegaly, secondary anaemia, leukopenia, and the gradual development of a chronic ankylosing arthritis. This syndrome was originally described by Felty in 1924. Attention is called to the fact that certain types of Gaucher's disease, associated with osteo-articular symptoms, as well as the anicetric type of Hanot's disease, associated with arthritis, may belong to the same category as those of Felty's syndrome. The author expresses no opinion as to the etiology of the condition, but feels that, in those cases in which blood cultures have been proved positive, the condition of a pseudorheumatic infectious splenomegaly has been mistakenly classified with the true splenomegalic arthropathies. Following the

opinion of Hanrahan and Miller, the author believes that all cases of splenomegaly associated with arthralgia should be submitted to splenectomy in the hope not only of ameliorating the arthralgia, but of leading to complete cure of the condition.—*Henry Milch, M.D., New York, N. Y.*

THE CLINICAL AND ROENTGENOGRAPHIC INTERPRETATION OF LUMBOSACRAL ANOMALIES. Albert B. Ferguson. *Radiology*, XXII, 548, May 1934.

Lumbosacral anomalies produce symptoms only through faulty mechanics. Faulty support or faulty relationship produces abnormal stresses or pressures. Whether an anomaly is due to faulty support or to faulty relationship, its mechanical weakness can be compensated by muscles and ligaments. As long as these soft tissues are of sufficient strength and tone to meet the conditions without fatigue, there are no symptoms—the patient is compensated.

Muscles and ligaments that are thus occupied in supporting or protecting the lumbosacral area have less than normal capacity for meeting extraneous loads or stresses, as a certain portion of their total capacity is already in use. Hence these tissues are more liable to strain than the normal,—that is, their capacity to meet stresses is more liable to be exceeded, in which event the patient is decompensated and must be relieved by rest in order that these injured tissues may recover and regain a state of compensation.

Decompensation occurs in several ways, which the author discusses in detail.

The conception of compensation and decompensation which has been stated points the way for the treatment or prophylaxis of these conditions. For mild cases it is essential to build up muscle tone and power sufficiently to meet the stresses,—that is, to keep the patient compensated.

The fusion operation, to eliminate motion and provide stability, is indicated when the attacks become so frequent and so severe that it becomes worth while for the patient to give up the time necessary for the operation in order to put an end to the attacks.

Many individuals have chronic arthritis in the spine as well as lumbosacral anomaly. Such cases are not favorable for surgery, as complete relief cannot be expected, due to the arthritis in areas which are not fused.

There is no positive differentiation by physical examination between lumbosacral anomalies and so called sacro-iliac strain. The results of surgical treatment indicate that, when there is no definite sacro-iliac abnormality visible in the roentgenogram, the lumbosacral area, rather than the sacro-iliac joints, must be suspected as the source of symptoms.

Our spines were developed for the four-footed position and are not yet adapted to the erect position, so that mechanical weakness at the lumbosacral area is usual rather than exceptional. We must consider the lumbosacral area not as normal or abnormal, but as mechanically sound or mechanically unsound. Stability, or sound mechanics, at the lumbosacral area depends in a great degree on the articulations of the lumbosacral arch. Considered mechanically, probably the worst type of facets are those which are asymmetrical.

The fifth lumbar vertebra may be displaced anteriorly on the sacrum. Although attacks of severe pain may be due to increase of displacement, most of them are due to strains which occur because of the mechanical weakness.

Posterior displacement of the fifth lumbar vertebra is one of the most common of the significant lumbosacral anomalies. The mechanism of the displacement is as follows: On hyperextension, the lumbosacral joint being hypermobile, the fifth lumbar vertebra glides backward on the first sacral vertebra,—an exaggeration of the normal motion. Then on flexion, instead of gliding forward, the fifth lumbar vertebra tilts forward, being caught in the position of posterior displacement. The displacement may often be reduced by reversing this process, extending the spine, and then gently flexing it with traction of the pelvis.

In a lumbosacral structure which is mechanically sound, the lumbosacral angle is more acute when standing than when lying, due to slight sagging forward of the pelvis on

standing. If, however, there is a mechanical weakness which is producing the symptoms, the patient, on standing, tilts the pelvis backward so as to reduce the lumbosacral angle and bring the sacrum more under the line of the weight thrust—a protective reaction. For this reason, the lumbosacral angle may appear worse in a normal subject when standing than in one who has lumbosacral weakness.

The anteroposterior mobility of the fifth lumbar vertebra should be determined, for the reason that abnormal mobility at this joint is just as much a mechanical weakness as is a bony anomaly. The amount of mobility is determined by making true lateral views in flexion and in extension. Fifteen or more degrees of anteroposterior motion, or a movement of the spines of the fifth lumbar and first sacral vertebrae of more than one-half inch in relation to each other, constitutes sufficient mobility to be a cause of symptoms.—*Edward N. Reed, M.D., Santa Monica, California.*

Post-Traumatic Para-Articular Ossification of the Knee Joint ("Köhler-Pellegrini-Stieda Shadow"). I. M. Odessky. *Radiology*, XXII, 701, June 1934.

The nature of this shadow is not wholly clear and there is some question as to the underlying lesion. It occurs following an injury—inflicted by either direct or indirect violence—or a series of small, repeated injuries. Several observers have considered the underlying lesion to be a fracture,—the separation of a bony lamella. Others believe it to be an ossification of periosteum separated by an injury. Pellegrini considered it a metaplasia of the connective tissue. Still others believe that this shadow is produced by lime salts deposited in a hematoma. Temler believes that the shadow corresponds with the intermuscular space between the vastus internus and the adductor magnus, that capillary hemorrhages into this space produce hematomata in a location where conditions for resorption are unfavorable, and that these hematomata subsequently calcify. Kulowski compares this disease to ossifying myositis.

The author discards the hypothesis of a lamellar fracture because of absence of the shadow immediately following the injury. Moreover, the outline of the femoral condyle shows no change. Also, the concomitant shadow shows a tendency to grow and to change in form, structure, and density. Furthermore, the shadow may diminish in size and even disappear.

Periosteal ossification would necessitate a connection of the shadow with the bone, which is usually not the case.

By means of technically irreproachable roentgenograms one can easily distinguish between the process of calcification and that of ossification. Study of the histological specimens argues against fracture and proliferation of the periosteum, and in favor of metaplasia of the tissues. The mechanism is identical with that of calcification in other tissues, such as the pleura, pericardium, pancreas, etc. Similar shadows are also found in other joints (leg, shoulder, elbow) which have been exposed to injury.

In the author's opinion, the so called Köhler-Pellegrini-Stieda disease is nothing more than a calcification or ossification of the knee joint, showing no consistent uniformity in clinical history for such classification, but forming a part of the general conception of post-traumatic, para-articular ossification.—*Edward N. Reed, M.D., Santa Monica, California.*

Pellegrini-Stieda's Disease: Clinical and Roentgenologic Consideration. Donald W. Hedrick and Horace C. Jones. *Radiology*, XXIII, 180, Aug. 1934.

Following trauma, periarticular calcification is frequently seen in the regions of the shoulder, elbow, hip, and knee. In the shoulder, this usually occurs in the subacromial bursa or in the supraspinatus tendon after a tear. Calcification and ossification are seen in the bursae of the elbow or in the soft tissues after extravasation of blood accompanying fractures. The bursae in the region of the greater trochanter of the femur are subject to trauma from direct blows and calcification is occasionally found here. The bursa between the gluteus maximus muscle and the trochanter is most often the seat of inflammation in this region.

Calcification and ossification, in the region of the medial femoral condyle, are considered to be important disease entities,—first described by Pellegrini in 1905 and now known as Pellegrini-Stieda disease. Stieda believed that fracture was the basic cause of the disease. The experimental work of Schüller and Weil has thrown doubt upon Stieda's original idea of fracture as the underlying cause.

Schüller and Weil, in 1923, injected an opaque substance into the tendon of the adductor magnus muscle in fresh cadavera and studied this condition experimentally. From the experiments, they concluded that the origin of the osseous mass was not from periosteum, but from connective tissue—a metaplasia resulting from a contusion or a tear caused by a strong contraction of the adductor magnus muscle.

Kulowski agrees that myositis ossificans is the basic pathological process. His operative findings substantiate this.

The x-ray findings in a typical case are as follows: There is a crescent-shaped opaque body with the concavity directed toward the condyle, but separated from the latter by a clear space. The ends are often slender. The subjacent condyle presents a normal silhouette. Nothing is seen which suggests any deformity of or depression in the internal condyle, such as might occur with an osseous tearing.

During the first week, the patient should be instructed to practise frequently active contraction of the quadriceps muscle to prevent atrophy. Weight-bearing may be started the second week, provided the knee is supported by a compression, elastic, or felt and flannel bandage. Diathermy is by far the most valuable of the physical therapeutic adjuncts. Massage is absolutely contra-indicated over or near the involved area. Surgery is indicated only in old cases, when the size of the mass interferes with the mechanics of the joint, but is to be thought of only after the calcification has reached completion.

Maffei rates the disability resulting from this disease at from five to ten per cent. Those cases of his which reached the Supreme Court were given fifteen per cent. disability. It is generally felt, however, that the true figure lies between five and twenty per cent.—*Edward N. Reed, M.D., Santa Monica, California.*

End-Results of Coxa Plana as Related to Treatment. Guy A. Caldwell. *Southern Med. J.*, XXVII, 402, May 1934.

According to some authors, the age of onset of the disease determines the extent of the final deformity. Legg says the prognosis depends upon the type, indicating that the mushroom type gives better results than the cap type.

Caldwell reports fourteen cases, with special reference to age of onset, time and character of treatment, and end results. Fewer bad results are seen among treated cases. Absolute fixation in plaster-of-Paris is probably unnecessary and leads to atrophy of the head and neck of the femur. The use of a caliper brace relieves the severe symptoms and, when the brace is applied early, the deformity is lessened. The brace is discarded shortly after symptoms become quiescent. Recalcification occurs promptly with minimal distortion of the epiphysis.—*Fred G. Hodgson, M.D., Atlanta, Georgia.*

Fractures of the Os Calcis. J. Edgar Stewart. *Southern Med. J.*, XXVII, 711, August 1934.

This paper is based upon the examination of thirty cases of fracture of the os calcis in which the records were complete. Twenty patients had returned to their regular work; two were retired on account of age; one had a mid-thigh amputation of the other leg; and the seven others had good useful feet, but for various reasons had not returned to their former work.

Treatment consists of elevation of the injured foot eight to ten inches, support of the sole by a splint, and constant application of ice bags. After a few days, the foot is manipulated under anaesthesia and a plaster cast is applied from the toes to the thigh. During the past three years, the Böhler method has been used. Three patients had a subastragalar arthodesis several months after injury.—*Fred G. Hodgson, M.D., Atlanta, Georgia.*

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